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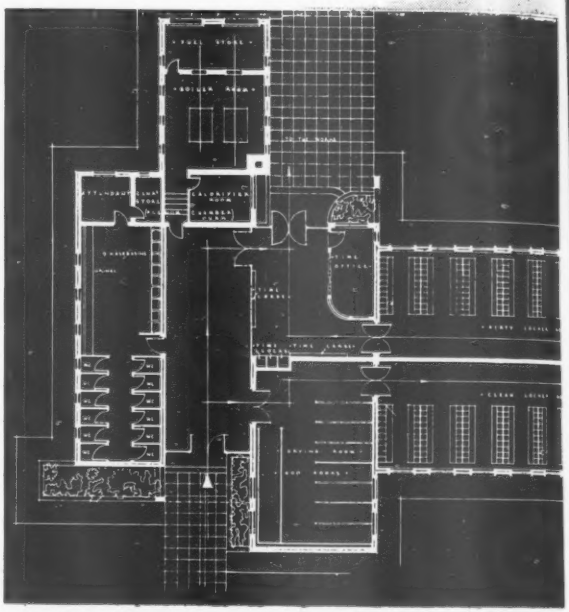

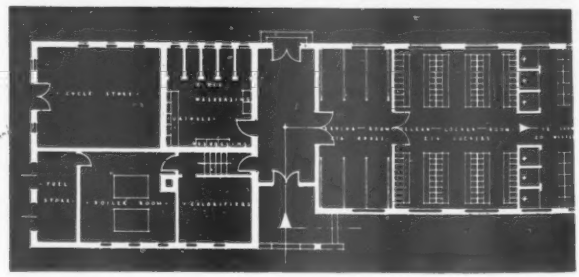

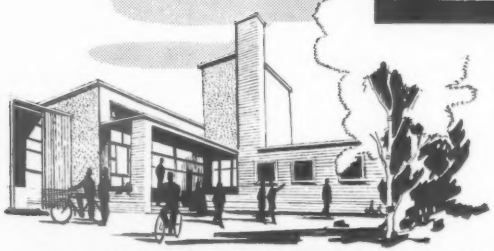

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PRINCIPAL CONTENTS

Technical: PAGE

Effect of Mould Material on the Solidification Rate of Cast Metals
Combined Report of the Sub-committee T.S. 21, 33 and 46 (mainly 46) of the Institute of British Foundrymen. Using the pyrometric method developed by T.S. 33 and standardizing the number of variables, experiments are detailed relating sand grain-size, ramming density, and coal-dust content, and their effects on the cooling rate of cast metals . . . 291

Spalling of Green-sand Moulds and its Relation to Casting Defects, by H. Pettersson:
This second part of the Paper embodies the Author's comments on his experimental data. He deals with the influence of gas pressure, thermal expansion, rate of heating, sands, benders and additives, and ramming density in relation to spalling. The defect is also related to normal sand testing methods and this theme is continued in the discussion . 301

Features:

Leader: Industrial Diseases 289
Correspondence 290
New Equipment 299
Publications Received, Book Review and House Organs 314
New Patents 316
Forthcoming Events (Advert. section) . 37

Commercial:

Iron and Steel Statistics 300
Company News 313
Contracts Open 313
Raw Material Markets 318
Current Prices of Iron, Steel and Non-ferrous Metals (Advert. section) . . 36

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Industrial Diseases

The Report has been published of the Beney Committee* which for the last two years has been investigating the question of industrial injuries not caused by accident, or, in plain English, to decide whether such ailments as rheumatism and bronchitis amongst workpeople are due to the conditions under which they work and, if so, should compensation be accorded. The majority of the Committee decided against any extension of the existing industrial-injuries scheme. It is obvious the Committee were impressed by the medical evidence submitted, which left their majority in no doubt that many of the questions that would arise if such diseases were admitted to the "industrial" classification would be unanswerable in the present state of medical knowledge.

If common ailments were to be included in the compensation scheme then "a man working out of doors might claim that ordinary climatic conditions were a cause of his arthritis. A clerk might allege that the sedentary nature of his work over many years was responsible for his chronic indigestion or even his coronary thrombosis. A manager, or someone else whose work involved mental stress, might claim that this was the cause of his peptic ulcer or perhaps of his neurosis. A labourer whose life had been spent doing heavy work might contend that this led to a variety of degenerative changes which amounted to premature ageing." From this quoted statement it can be assumed that some sort of ailment could be associated with any occupation—be it writer's cramp, tennis elbow, or housemaid's knee.

The situation at the moment is that the Minister, if he be satisfied that a disease ought to be treated as a risk of occupation and not a risk common to everybody, then he may prescribe it. This word "prescribe" must mean the enactment of legislation to take care of the situation. The Beney Committee, including the minority dissenting from the main Report, favoured the prosecution of research into occupational health hazards so that prescription can be rendered effective. This will involve proof that, say, rheumatism is more prevalent amongst farm labourers than it is with their wives or a general cross-section of the population. The three members of the Committee who supported the minority viewpoint do not accept the conclusions reached by their fellow members on the impracticability of making more comprehensive cover available against diseases under the industrial-injuries scheme. Thus, the major divergence boils down to whether any extension—under existing knowledge—is or is not practical.

* Report of the Departmental Committee to Review the Diseases Provisions of the National Insurance (Industrial Injuries) Act; published by HM Stationery Office, York House, Kingsway, London, W.C.2; price 1s. 4d.

Correspondence

FOUNDRY DICTIONARIES

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—On page 138 of the FOUNDRY TRADE JOURNAL (August 11) you announce the provisional publication of an International Foundry Dictionary and invite comments.

We have ordered a copy of this but until its receipt and perusal cannot fairly comment upon it; but there is one aspect of foundry "language" which must occasion difficulty and, maybe, confusion at all levels within the industry. I refer to the local variation of the customary meaning of a word or term. This sometimes leads to arguments and waste of time which could be avoided if the parties concerned had commenced their conversation by making sure that they were all using the same "language," *i.e.*, all using a particular word to mean the same thing. For example: (1) I have heard the term "core print" used to refer to (*a*) the extension on the core itself; (*b*) the locating cavity in the mould which receives this extension, and (*c*) the extension on the main pattern which gives rise, in moulding, to the cavity. (2) I have heard brassfounders refer to zinc oxide as sulphur. (3) "Fettling," in some localities, is a process of "dressing" castings (*i.e.*, removing fins, flash and such like). The same term is used for the operation of repairing furnace-hearths. (4) Does the word "investment" refer to a *complete* method of making castings (*i.e.*, the "investment process") or does it refer to the isolated operation of covering something (Latin—*Vestis*—a garment), or does it refer to the *material* used in the "investment process"?

I therefore think that any dictionary, whether national or international, should be emphatically prefaced (in all the languages concerned) with some reference to this matter and such preface should "warn" all who consult the dictionary (i) that many foundry terms *are* subject to considerable ambiguity of meaning, that such ambiguity is likely to be aggravated in international translation and (ii) that it can best be removed, so far as a technician, lecturer, salesman, customer or other joint party to a conversation, letter or lecture is concerned, by the framing of an *ad hoc* definition at the time.

I am sending a copy of this letter to the secretary of the Institute of British Foundrymen.—Yours, etc.,

THOMAS B. CROW.

Foundry Services, Limited,
Birmingham.
August 30, 1955.

[It is possible that Dr. Crow is mentally confusing a dictionary with an encyclopædia. As a newcomer to the International Dictionary Committee, I have been agreeably surprised at the system used. For instance, being recently engaged on a section devoted to pattern-making, I had the task of translating *Portée à l'anglaise* —which translated as "English-type coreprint" means exactly nothing. Yet as it was defined in French, it was possible, by the use of a short expression, to give a satisfactory translation, but only after consulting a practical patternmaker. EDITOR.]

INSTITUTION OF MECHANICAL ENGINEERS, 1, Birdcage Walk, Westminster, London, S.W.1, has just issued a brief subject and author index of the papers they have published during the period 1937 to 1954. Eleven papers on various aspects of foundry practice have been listed. In the early days of the Institution, foundry practice figured prominently, then there was a long period of neglect, so that it is pleasing to find a resurgence of interest.

Recuperator Tubes

A conference on steel-tube recuperators is to be held in Paris, on September 27 and 28, under the auspices of SETREM (*Société Equipments Thermiques et de Recuperateurs Metalliques*), Paris, Rekuperator K.-G., Dusseldorf, and Metallurgical Engineers, Limited, London. The venue is Salle la Rochefoucault-Liancourt, Siege de *L'Association des Ancien Eleves des Ecoles D'Art et Metier*, 9, Avenue D'Iena, and the programme will be initiated by Mr. X. Trevoux of SETREM, speaking in French, his address being later given in English by Mr. F. C. Evans, F.I.M., of Metallurgical Engineers, Limited. Other speakers include Dr. A. Schack, on the theoretical basis of heat recovery, Mr. N. H. Turner, on recuperators at Appleby-Frodingham Steel Company, Limited, and Mr. R. Burleigh, International Combustion, Limited, on hot-blast cupola practice. Radiation recuperators and dust problems in relation to recuperators are among the topics also to be discussed during the first day. The Wednesday is to be devoted to a visit to the works of Comptoir D'Etirage et de Profilage des Metaux at Persan, and a lecture on the "Manufacture of Heat-resisting Steel Tubes by Extrusion." Full particulars may be obtained from Mr. F. C. Evans, Metallurgical Engineers, Limited, Granite House, Cannon Street, London, E.C.4.

Latest Foundry Statistics

According to the Ministry of Supply, the production of aluminium castings during June was 1,816 tons from sand moulds; 4,522 as gravity-die and 1,655 tons as pressure-die-castings. The output of magnesium-alloy castings was 401 tons.

The Council of Ironfoundry Associations announces that employment in iron foundries during the week ending July 2 was 143,849. The corresponding earlier figures were May 28, 1955, 144,502, and July, 1954, 139,002.

As reported by the British Bureau of Non-Ferrous Metal Statistics, the production of copper-alloy castings for the first six months of the year was 31,391 tons as against 31,198 tons in 1955. The June output was 5,451 tons.

Index to Vol. 98

The index to the JOURNAL, volume 98, covering the period January to June, 1955, has now been printed and is available to readers free of charge. Applications for copies should be addressed to the publishing office, FOUNDRY TRADE JOURNAL, John Adam House, John Adam Street, Adelphi, London, W.C.2. Subscribers who wish to receive copies of indices automatically as they are printed may apply for inclusion on a permanent mailing list. Those already on this list should not need to apply for their current copy.

LONDON COUNTY COUNCIL is providing a course of five lecture demonstrations in foundrywork for handicraft teachers in the area. Mr. A. Talbot, manager of Western Foundries, Southall, is conducting the course, in the arrangement of which the L.C.C. has been advised by the Council of Ironfoundry Associations. The classes, which started last Tuesday evening (September 13), are held at the Sir William Collins secondary school, Medburn Street, London, N.W.1.

Effect of Mould Material on the Solidification Rate of Cast Metals*

Combined Report of IBF Sub-committees T.S. 21, 33 and 46†

The first committee to investigate this work started in 1947 with the following terms of reference:—"To determine the influence of mould materials on the rate of solidification of cast iron by the interrupted-freezing method." The Metallurgy Department of Birmingham University, to whom grateful acknowledgment is made, co-operated with this sub-committee and have done so throughout this and subsequent work. It was thought that the rate of solidification of a casting could be conveniently defined as the speed of movement of the solid/liquid metal interface away from a mould wall, and that by "slushing" a casting it would be possible to study this movement. The slush-casting method consists of filling a mould with molten metal and, after a pre-determined time, breaking the mould open at the bottom of the mould cavity or inverting the mould, thus allowing that part of the metal still liquid to flow out. The shell or crust thus formed is then weighed or measured, the assumption being that the greater the cooling power of the mould material used, the greater the shell thickness for a given time of standing before slushing. The conclusions drawn from experiments with this method are:—(a) That it is insufficiently sensitive to determine the difference in cooling power of different types of sand and (b) that in all pure metals, or alloys freezing at a constant temperature, there exists a zone of partial solidification between the all-liquid and all-solid zones and this makes the definition of the solidification rate difficult. The next approach to the work was to investigate the suitability of the pyrometric method for investigating the rate of solidification of cast metals. This work was done by sub-committee T.S. 33 and consists of placing one or more thermocouples in selected positions in the mould cavity or mould material or both, and recording the temperature changes with a one-second-response temperature recorder, or high-speed galvanometer, from the moment of pouring the metal into the mould until solidification is complete. This method proved quite successful, provided certain precautions were taken to prevent variations in results. The main precautions to be taken are: (a) sand density and moisture content must be controlled; (b) casting size must be suitable; and (c) pouring temperature and casting speed must be controlled and splashes eliminated.

The main investigation was carried out by sub-committee T.S. 46 using this method and, by standardizing all variables, very good reproducibility was obtained. Some of the general conclusions to be drawn from this work are: (a) That the coarser the sand the greater its cooling power at a given ramming density; (b) the harder a mould is rammed the greater its cooling power at a given ramming density, other variables being the same; (c) the higher the moisture content of a sand the greater its cooling power when all other variables are equal; and (d) the presence of coal-dust causes some increase in the cooling power of the mould in the case of casting sections up to 1½-in. thick. This work was carried out with natural and synthetic sands generally used in the British Isles. Other types of sand and moulding materials have still to be investigated.

Preface

The work referred to in this Report was started in March, 1947, as a result of a supplementary Report presented to the Technical Council by sub-committee T.S. 7 (Mould Materials for Iron Castings), which suggested two sub-committees be set up to carry out researches into (*a*) methods of evaluating soundness and (*b*) to determine the influence of mould materials on the rate of solidification, as a means of carrying out the researches proposed in the original T.S. 7 Report presented in September, 1946.

As a result of the supplementary Report, the Technical Council appointed sub-committee T.S. 21 with the following terms of reference:

> "To determine the influence of mould materials on the rate of solidification of cast iron by the interrupted-freezing method."

Mr. L. W. Bolton agreed to act as chairman. The Technical Council suggested that T.S. 21 might usefully take advantage of the facilities offered at Birmingham University by Professor L. Aitchison and later, by Professor A. J. Murphy. This suggestion was acted upon and Dr. V. Kondic of the Industrial Metallurgical Department indicated his willingness to assist in the work. In practice this has meant that the pure research and most of the practical work

*Presented at the fifty-second annual meeting of the Institute of British Foundrymen and International Foundry Congress in London last June.

†Constitution of the sub-committees is quoted overleaf.

of the sub-committees over the past seven years has been done by the research students of the University, with the sub-committees acting as guides and directing the work. The Council of the Institute of British Foundrymen and the sub-committees are indeed grateful for the work done and help given by the University.

In this investigation of the effect of moulding material on the solidification rate of cast metals, the sub-committee thought that the effectiveness of using the age-old practice of putting raw red sand in moulds, on bosses and at the junctions of thick and thin sections, to prevent sinking or drawing, would be proved or disproved. Although this practice had stood the test of time and is widely used in many foundries there appeared to be no obvious explanation of the advantages claimed by its users.

WORK OF T.S. 21

Introduction

The study of the solidification of cast metals and cast iron in particular, covers a wide field of subjects and is complicated by the number of variables involved. It was thought that the rate of solidification of a casting could be conveniently defined as the speed of movement of the solid metal interface away from the mould wall. It was realized that this definition would be satisfactory only for solidification under non-equilibrium conditions.

It was assumed that after pouring a mould, the solid-metal crust forms at the mould surface, and thickens at a speed depending on the rate at which heat is extracted by the mould. The rate of solidification of a casting is consequently affected by the thermal properties of the mould and metal, by the type of casting, and by pouring temperature. The object of the work of the first sub-committee was to establish the effect of mould materials on the rate of solidification. Therefore, the other two factors—metal and methods of casting—had to be standardized.

The application of the interrupted-freezing or slush method of casting for the measurement of the rate of solidification was based on the assumption that the thickness of the solid shell obtained was, in effect, the distance to which the complete solidification of the casting had progressed. The ideal material for the application of this method for the measurement of the rate of solidification is, therefore, one which solidifies at a constant temperature, as the solid/liquid interface should then be a smooth surface. (For experimental detail and results see Appendix "A.")

Summary of Results

Whilst the results obtained failed in attaining the ultimate objective of the investigation, nevertheless certain interesting and valuable observations were made which throw some light on the problems of the mechanism of solidification.

The progress of solidification from a flat or cylindrical surface is one of the points of interest. Under the conditions used in this work, it appears that the shell thickness formed from a flat surface follows a straight-line relationship to the $\sqrt{\text{time}}$. The value of this relationship in studying the rate of solidification is considerable, as it makes it possible to obtain a number of interesting data, from only a small number of "slushed" castings. By extending the straight line where it cuts the "X" or time axis, the time can be obtained from the moment of filling to the moment for the starting of solidification in the mould. The end point of solidification of the casting can be obtained by drawing a horizontal line parallel to the "X" axis and at a distance corresponding to half the thickness of the casting. This conclusion was checked with commercially-pure aluminium in the following way:—A thermocouple (the hot-junction of which was only lightly coated with alumina) was inserted in the centre of a rectangular mould and a cooling curve taken under

CONSTITUTION OF THE SUB-COMMITTEES

J. Hird (*chairman of T.S.* 46 *and T.S.* 33 *and a member of T.S.* 21).

D. W. Berridge (*T.S.* 46).

†*J. T. Berry, B.Sc., Ph.D.* (*T.S.* 46).

L. W. Bolton, A.M.I.Mech.E., F.I.M. (*chairman of T.S.* 21 *and a member of T.S.* 33).

E. R. Dunning (*T.S.* 21 *and T.S.* 33).

J. H. Gittus, B.Sc. (*T.S.* 33 *and T.S.* 46).

S. J. Heritage (*T.S.* 46).

**V. Kondic, B.Sc., Ph.D.* (*T.S.* 21, *T.S.* 33, *and T.S.* 46).

R. Lee, A.Met., F.I.M. (*T.S.* 46).

†*G. Martin, B.Sc., Ph.D., G.I.Mech.E.* (*T.S.* 33, *T.S.* 46).

P. Robinson (*T.S.* 21).

R. W. Ruddle, M.A., F.I.M. (*T.S.* 21, *T.S.* 33, *and T.S.* 46).

P. A. Russell, B.Sc. Met., F.I.M. (*T.S.* 21 *and T. S.* 33).

G. R. Shotton (*T.S.* 21, *T.S.* 33, *and T.S.* 46).

†*D. Snelson, B.Sc.* (*T.S.* 21).

A. Tipper, M.Sc., F.I.M. (*T.S.* 21, *T.S.* 33, *and T.S.* 46).

G. Lambert (*T.S.* 21, *T.S.* 33, *and T.S.* 46), *Secretary.*

* Lecturer in industrial metallurgy, University of Birmingham. † Research student in industrial metallurgy, University of Birmingham, for part of the period during which this work was done.

otherwise identical mould and metal conditions. The time obtained for complete solidification checked satisfactorily with the results shown in Fig. 29 in Appendix "A."

The difference in behaviour of solidifying metal surfaces is another point of interest arising from this work. In a pure metal, there is a sharp line of demarcation between the solid and residual liquid at all stages during solidification, so long as even the smallest temperature-gradient exists. With a rapid rate of cooling, the surface between the solid and liquid is very smooth, and with slower cooling, it is slightly corrugated. The presence of small amounts of impurities leads to further roughening of the surface. The addition of alloying elements, which create a solidification interval, still further roughens the surface, and after a certain amount of shell has formed the alloys cannot satisfactorily be "slushed" at all. The main reason for such behaviour lies in the fact that with alloys solidifying over a temperature range, "all-solid" and "all-liquid" zones are not separated by a surface but by a "pasty zone," the depth of which depends on the length of the solidification interval of the alloy and the rate of cooling (on which depends the magnitude of the temperature-gradient).

In order to check the validity of this explanation, cooling curves were taken by using two thermocouples, one at the surface and one in the centre of the casting. Commercially-pure aluminium and high-phosphorus cast iron were used for the test. The temperature differences during the arrest point in the cooling curves were:—Commercially-pure aluminium, surface 644 deg. C., centre 655 deg. C., and high-phosphorus iron, surface 1,072 deg. C., centre 1,090 deg. C. This shows that for the type of mould used the difference in temperature between the centre and the outside is small and any alloy having a solidification interval of the order of 10 to 20 deg. C. will have a deep pasty zone. In "slushing" such a mould, the liquid cannot run out freely; consequently, the thickness of the shell may be at any fortuitous depth of the pasty zone. This is the main reason why the experimental method used was not successful for studying the rate of solidification of cast iron.

The variation of the shell thickness in relation to the type and condition of the sand was the main object of this work. Any difference in the shell thickness arising through the differences in mould materials could only be due to differences in the cooling power of the mould materials, *i.e.*, heat absorption (or generation). In the experimental conditions used, there was a period varying between one and three minutes before any solidification started. It appears the heat absorption was not sufficient to affect the heavy mass of metal used in the experiments, and that such variations as may have existed in the thermal properties of the sand were not large enough to be detected by the methods used.

Conclusions

1. The slush method is not sensitive enough to determine the difference in chilling power of different types of sand.

2. An added difficulty is introduced by the existence of a zone of partial solidification between the "all-solid" and "all-liquid" regions in all but super-pure metals and alloys freezing at constant temperatures; this makes the definition of solidification rate difficult.

WORK OF T.S. 33

In order to overcome the difficulties encountered by sub-committee T.S. 21, it was necessary to investigate other experimental methods, consequently a new sub-committee T.S. 33 was formed in 1949, and

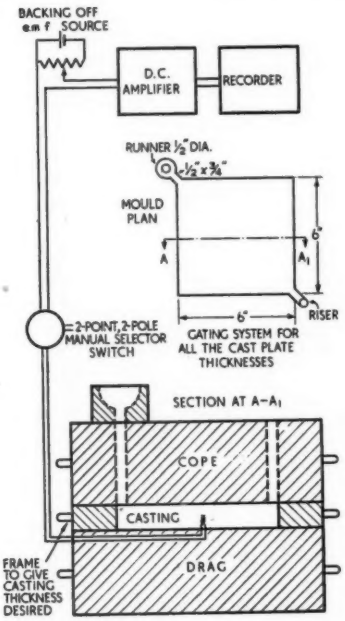


FIG. 1.—*General layout for the solidification experiments using ¼- and ½-in. plates—thermocouple in the casting.*

T.S. 21 was dissolved, most of its members agreeing to serve on the new sub-committee, whose terms of reference were:—

> "To explore the suitability of the pyrometric and alternative methods for investigating the rate of solidification of cast iron."

This sub-committee first concentrated on the pyrometric method which consists of placing one or more thermocouples in selected positions in the mould cavity or moulding sand or both, and recording the temperature changes with a one-second-response temperature-recorder or a high-speed galvanometer from the moment of pouring the metal into the mould until solidification was completed. It was

hoped that the time of complete solidification of the casting would prove to be a measure of the chilling power of the mould material and would thus avoid the difficulties connected with the solidification rates found in the T.S. 21 experiments.

Experimental Methods

As the work of T.S. 21 had shown that rectangular castings were better for this work than cylindrical ones, it was decided to use plates 6-in. by 6-in. and of various thicknesses. Fig. 1 shows diagrammatically the general layout of the equipment for these

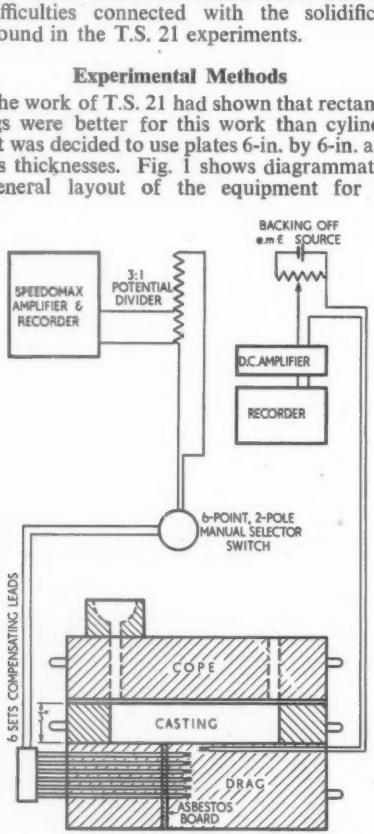


FIG. 2.—*Layout for the solidification experiments employing the 3-in. block—thermocouples in the sand and the castings.*

experiments when casting plates ¼- to 2½-in. thick with the thermocouples in the casting. Fig. 2 shows the layout for plates 3-in. thick, with the thermocouples in the sand and the casting. Fig. 3 is a general view of the apparatus.

Experiments using this method, and hand ramming the moulds to a known mould-hardness figure, gave results which had a poor reproducibility and were somewhat disappointing. However, two important conclusions were drawn which later proved to be correct; first, that mould density is of paramount importance and, secondly—a point that had become apparent in the slush-casting experiments—that owing to its long freezing-range it is not possible to determine the exact solidification point of cast irons.

It was therefore decided to modify the method to eliminate, as far as possible, these two causes of unreproducibility. The moulds were next rammed by squeezing a weighed amount of sand into the moulding boxes on a moulding machine. Tests showed that hardness varied little over the cross-section of the mould, although the corners tended to be softer. After ramming, the weight of the mould was checked and the moulds remade if their weights differed by more than 2 oz. After drying at 200 deg. C. for six hours and cooling to room temperature, the moulds were cast with eutectic (8 per cent.) aluminium bronze, at 1,250 deg. C. The melting point of the alloy is 1,038 deg. C. and the

TABLE I.—*Times for Total Solidification of 6-in. by 6-in. Plates Cast in Aluminium-bronze.*

Sand.	Kind of mould.	Plate thickness (in.).	Mould density (gm. per c.c.).	Solidification time (sec.).
Bromsgrove (dry)	Medium rammed	1	1.395 1.390	378 396
			av. 1.392	av. 387
Bromsgrove (dry) (plus 8 per cent. coal-dust)	Medium rammed	1	1.381 1.377	336 324
			av. 1.379	av. 330
Fine sand (dry) ..	Soft rammed ..	1	1.167 1.175 1.175	449 445 437
			av. 1.172	av. 444
Fine sand (dry) ..	Medium rammed	1	1.351 1.355 1.355 1.355 1.360 1.363	391 392 393 399 377 388
			av. 1.356	av. 390
Coarse sand (dry)	Medium rammed	1	1.447 1.447 1.447	307 291 289
			av. 1.447	av. 296
Fine sand ..	Hard rammed ..	1	1.417 1.425 1.430	354 352 354
			av. 1.424	av. 353
Coarse sand (dry)	Hard rammed ..	1	1.544 1.544	288 306
			av. 1.544	av. 297
Fine sand (green) (moisture 3.2 per cent.)	Medium rammed	1	1.368 1.368	330 315
			av. 1.368	av. 322
Coarse sand (green) (moisture 2.1 per cent.)	Medium rammed	1	1.526 1.535	270 296
			av. 1.530	av. 283
Fine sand (dry) ..	Medium rammed	3	1.336 1.344	1,080 1,095
			av. 1.340	av. 1,087
Coarse sand (dry)	Medium rammed	3	1.406 1.446	828 996
			av. 1.426	av. 912
Fine sand (dry) (plus 8 per cent. coal-dust)	Medium rammed	3	1.340 1.336	912 1,002
			av. 1.338	av. 957

heat content corresponds approximately to the heat content of cast iron, poured with 100 deg. C. superheat.

In order to compare the solidification times of aluminium-bronze with that of cast iron, two moulds were made, using fine sand and plates 1-in. thick—one to be cast in aluminium-bronze at 1,250 deg. C. and one in cast iron, also at 1,250 deg C. The aluminium-bronze gave a solidification time of 430 sec. and the cast iron 475 sec. Allowing some error on account of the difficulty of ascertaining the end point of solidification of cast iron, the results do show that if poured at 1,250 deg. C. the two metals have approximately the same solidification times. A graph showing typical solidification curves for aluminium-bronze and a cast iron is given in Fig. 4. This shows the absence of a definite end-point in the curve for cast iron and a clear end-point for the aluminium-bronze.

A series of experiments was now carried out using the modified method, and the results shown in Table I give much better reproducibility and emphasize the effect of varying mould-densities on the solidification times of plates 1-in. thick.

Conclusion

This method gives results which compare the cooling power of different moulding-materials, under a variety of conditions providing that the following precautions are taken:—

(1) Sand bulk-density and moisture content must be accurately controlled.

(2) The casting must be large enough to give a reasonable solidification time and designed to reduce convection currents during solidification.

(3) Gating and pouring must be standardized.

(4) Casting "flash" must be excluded by careful moulding.

(5) Pouring and mould temperatures must be controlled; an immersion thermocouple is essential.

It was found that mould temperature variations of up to 50 deg. C. above room temperature had no significant effect on the solidification times.

The sub-committee was of the opinion that the method they had developed for investigating the solidification rate of cast iron was capable of giving a satisfactory result, provided that the technique was not dependent on the measurement of the end-point of solidification. It was recommended that the time required for the casting to cool to an arbitrary point below the eutectic temperature be taken, say, 1,050 deg. C. It was also proposed that in future work time/temperature readings be taken in the casting only. Data of equipment used in these experiments are given in Appendix "B."

The sub-committee also investigated an alternative method of comparing the cooling of different mould materials based on the laws of heat-transfer and developed by Chvorinov.[1,2] It consists of determining a series of time/temperature curves by means of thermocouples located in the moulding material at various distances from the interface. It was found that this was only practical on plates 3-in. thick, as thinner plates had too short a solidification time. From such curves the mean thermal diffusivity of the moulding material can be calculated. The accuracy of the method depends on the accuracy of the measurement of the distance between the interface and the thermocouples and on the uniformity of density of the rammed moulding material. A certain mathematical skill is required

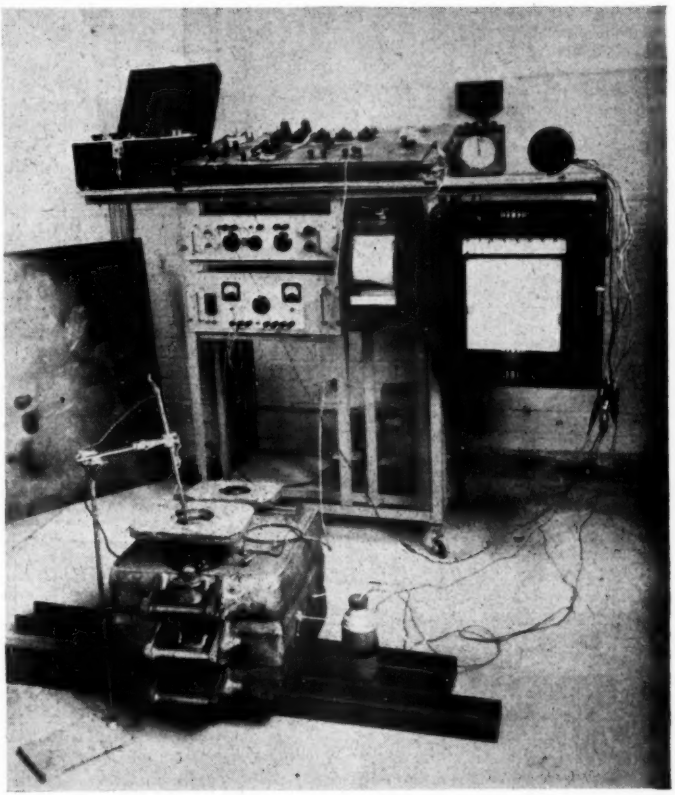


FIG. 3.—*General view of the apparatus for the pyrometric method of studying the solidification rate of cast metals.*

Effect of Mould Material on Solidification of Metal

for the evaluation of the results, but, once this is obtained, the cooling power in absolute units can be calculated.

It was, therefore, recommended to the Technical Council of the Institute that the method of using a thermocouple in the casting was a satisfactory method of comparing cooling power of moulding sands.

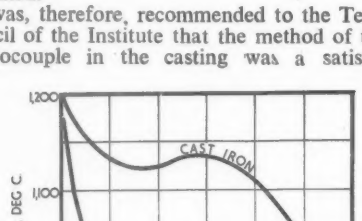


FIG. 4.—*Typical solidification curves for aluminium-bronze and cast-iron plates* 6- *by* 6- *by* 1-*in., poured at* 1,250 *deg. C. into fine, dry-sand moulds of density* 1.36 *gm. per cc.*

WORK OF T.S. 46

The sub-committee had now completed its work within the terms of reference of T.S. 33, and on the basis of its recommendations a new sub-committee, T.S. 46, was formed. Many of the members of the T.S. 33 sub-committee again agreed to serve on the new sub-committee, which had the following terms of reference:—

"To investigate the effect of mould material on the cooling rate in the solidification range of cast metals, with particular reference to cast iron."

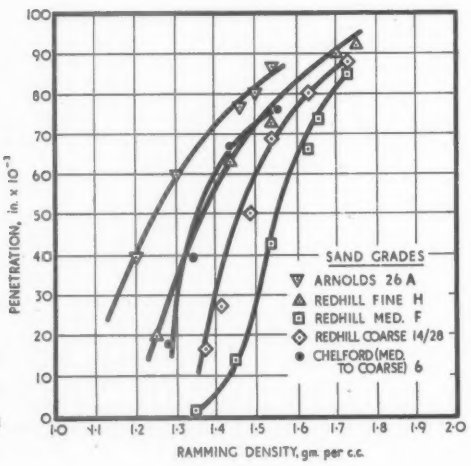
Choice of Casting Medium

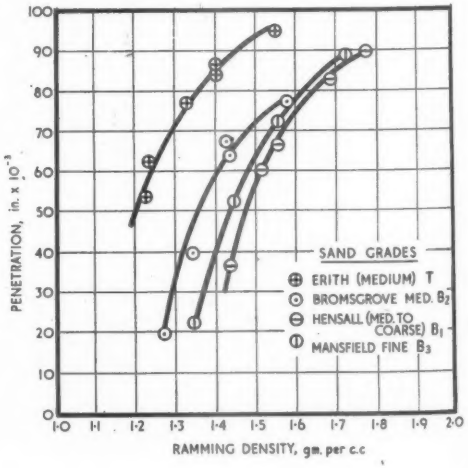
Before commencing practical work, it was agreed by the sub-committee, that in order to get a satisfactory end-point of solidification 8 per cent. eutectic aluminium-bronze be used as the casting medium. This alloy has a similar heat content to cast iron when cast in the same temperature range. However, in order to meet the terms of reference and to confirm the influence of the variables investigated, it was decided that check tests would be made with cast iron.

Work on Sand Density

As the importance of ramming density had become very clear in the experiments carried out by sub-committee T.S. 33, it was decided to carry out a survey on sand density and the most practical method of obtaining a uniform mould. Experiments were carried out with Bromsgrove sand to obtain a constant density in the mould not only in the horizontal direction but also vertically. Many methods were tried and, whilst some gave constant vertical density, the time involved to achieve this made them impractical. Eventually, it was decided to adopt a three-squeeze method of producing the 3-in. deep cope and drag moulds. The method consists of estimating the weight of sand required to fill the box to the desired density, and dividing this weight of sand into three equal parts. One part is sieved into the moulding box and levelled, a 2-in. wooden block is placed on top of it and the squeeze machine is operated, the top edge of the box acting as a stop for the squeeze-

FIGS. 5 AND 6.—*Relation between ramming-density and mould-hardness for synthetic* (*Fig.* 5) *and natural sands* (*Fig.* 6).

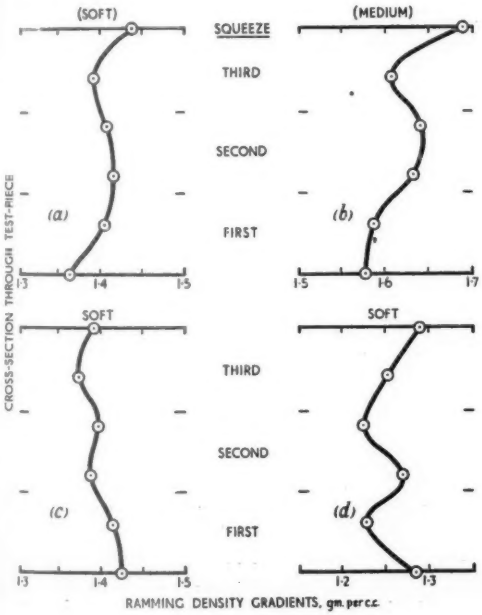




head. This produces a mould 1-in. thick in the bottom of the box. A second portion of sand is added to the box and a block 1-in. thick is also added, the machine being again operated. The final portion of sand is next added to the box and the machine squeezed a third time, without the use of a wooden block.

In the case of hard-rammed moulds, the ramming of the three weighed layers was carefully carried out by a moulder. The centre mould-part forming the vertical sides of the mould cavity was in all cases made by squeezing a weighed amount of sand around a wooden pattern. The results obtained by this method were first checked by cutting away half the mould with a sharp thin tool and measuring the hardness values on the exposed vertical face with a standard "Ridsdale" mould-hardness tester at ¼-in., ½-in. and 1-in. depths from the mould face along parallel lines at 1-in. intervals. Determination of the ramming-density gradients in the mould was subsequently carried out by making models of the mould in a sleeved horizontally layered corebox.[3] Use of the corebox enables layers of a compact to be removed and weighed. The model is of such proportions that approximately the same conditions of wall drag are maintained as in the actual mould. Mould-hardness measurements on the sheared-off portions of the model were also taken and recorded.

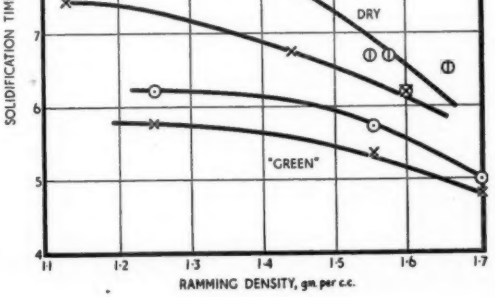
FIG. 7.—*Typical density-gradients in the "green" state for various moulds, using* (*a*) *Redhill, coarse* (14/28); (*b*) *Redhill, medium* (*F*); (*c*) *Mansfield and* (*d*) *Erith sands.*



In addition to compacts made in a similar way to the actual mould, specimens of all the sands were compacted in the corebox by a double-compression method (ensuring that little or no density-gradient was present) and mould-hardness determinations were carried out on the sheared-off, layers, giving at least 24 readings through each model. Such models were made for all the sands in the "green" state, over the range of ramming densities used. This was done to calibrate the Ridsdale mould hardness scale in terms of ramming-density. The relation between ramming-density and mould-hardness (or penetration) has a characteristic form for each sand examined, as shown in Fig. 5 for synthetic sands and in Fig. 6 for natural sands. By means of these curves, the gradients of ramming-density throughout the moulds made by the treble-squeeze method, or by any other method, could be obtained by measuring hardness on the surface of the sheared-off layers after the removal of loose sand. This method gave identical results with that involving the weighing of the layers and in addition was much more rapid. Typical density-gradients in the "green" state are shown in Fig. 7. The density-gradient in the dried state was calculated, assuming that the percentage moisture loss in the model was equal to that in the actual mould for all densities.

A series of experiments was now carried out to study the effect of ramming-density on the solidification time of 6- by 6- by 1-in. plates. Bromsgrove sand was used in the "green" and dry state, with and without 8 per cent. coal-dust were used, and Mansfield sand dry, without coal-dust. The results of these experiments are shown in Fig. 8.

FIG. 8.—*Effect of ramming density on the solidification time of* 6- *by* 6- *by* 1-*in. plates, using Bromsgrove sand* (*B.*2.), *Mansfield, fine sand* (*B.*3.) *and Bromsgrove sand plus coal-dust* (*B.*2*B.*) *in the "green" and dry states.*



Effect of Mould Material on Solidification of Metal

From this work certain conclusions were drawn for the particular sand condition and size of casting used. It is emphasized that these conclusions only apply to alloys, such as cast iron, brasses and bronzes generally, which are cast and freeze in a temperature range approximating to that studied, namely 1,000 to 1,300 deg. C.:—

(1) The influence of mould density was confirmed, the rate of solidification increasing progressively with increasing density within the limits investigated.

(2) The cooling power of green-sand is greater than that of dry-sand over the range of density investigated.

(3) The cooling power of sand in either "green" or dry state is increased by the addition of coal-dust.

(4) The increase of cooling power brought about by the presence of moisture and coal-dust (and probably of other carbon additions) is not so pronounced at high as at low ramming-densities.

This work also shows that in addition to the type of sand and its ramming density, the moisture content and coal-dust additions influence substantially the solidification time under the conditions used. Consideration of these variables was therefore added to the programme of work to be investigated. It was considered that another possible variable not shown up in this series of experiments was the effect of varying the volume of metal cast, and this was also added to the programme.

(To be continued)

REFERENCES.

[1] N. Chvorinov, *Giesserei*, 1940, **27**, 177, 201, 222.
[2] R. W. Ruddle & A. L. Mincher, *J. Inst. Metal*, 1949–50, **76**, 43.
[3] W. Davies & W. J. Rees, *J. Iron Steel Inst.*, 1944, **2**, 36.

Production Engineers' Awards

Presentation of the awards made by the Institution of Production Engineers for the 1953-54 session will be made at the annual dinner in October. The silver medal for the best paper presented by a member has been awarded to Mr. K. J. Hume, chief education officer of the Dowty Group, Limited, for his paper on the fundamentals of gauge design, while the award for the best paper presented by a non-member goes to Mr. F. Nixon, assistant general manager responsible for new manufacturing processes at Rolls-Royce, Limited, for his paper on effective utilization of materials. The Hutchinson memorial award for the best paper presented by a graduate member has been won by Mr. G. Cubitt-Smith, production officer in charge of the machine fabrication department of Crompton Parkinson, Limited, for his paper on resistance welding in America.

Because of the high quality of the candidates, it was decided to award two Schofield scholarships this year. Mr. R. W. Pickard, technical assistant to the general works manager, C. A. Parsons & Company, Limited, and Mr. H. S. Woodgate, process planning engineer of Fairey Aviation, Limited, are the recipients.

High-pressure Jets for Cleaning Machined Castings*

Extreme cleanliness is vital to all parts ready to be assembled into an automatic transmission. Without it, the performance of such a precise mechanism is likely to be seriously impaired. Consequently, all parts entering the air-conditioned assembly department must undergo thorough cleaning to remove all chips, burrs and other foreign matter.

To do this job effectively the Decatur (Illinois, USA) transmission plant of Marvel-Schebler Products Div., Borg-Warner Corporation, uses a new international washer. Its precise indexing device is so arranged that jets of hot high-pressure cleaning solution are registered with several machined holes through which the solution flows. With this set-up, all chips the holes may contain are completely removed.

Air Device for Location

This cleaning operation is performed after machining and is additional to prior washing of the grey-iron castings by the Kolene process which thoroughly removes all traces of core sand. The new washing machine is 31 ft. long, 8 ft. wide and 6 ft. high. It includes solution tanks heated by steam coils. In addition to a general spray washing of the transmission cases as they are advanced by the machine's conveyor, there is a special pressure-header box containing the set of high-pressure spray nozzles. An air cylinder actuated by limit switches and solenoid valves, and working in conjunction with a Geneva-type indexing device, momentarily locates each transmission case passing through. Thus, the set of high-pressure spray nozzles are lined up with the numerous machined holes in the casting.

Serving these nozzles is a pump, driven by a 20-h.p. motor and delivering hot cleaning solution under a 28-ft. head. Spray from these nozzles enters each hole at such high velocity that all chips in its path are cleaned out. After release of the casting from the indexed station, and further general spray washing, it continues along the conveyor past an air blow-off station. The case is then kicked off the conveyor on to a belt and carried by gravity rollers to an inspection station.

The washer also includes an automatic self-cleaning filter and a magnetic separator which remove all foreign matter before the emulsion cleaner is recirculated. Circulation is at the rate of 150 galls. per min., providing unusually thorough washing.

* Reproduced by permission of the Editor of *Iron Age*

New Model

Grange-Camelon Iron Company, Limited, one of the Federated Foundries group, introduced in London recently a new model of a free-standing solid-fuel fire known as the Sofono Sunray Homeheater. In compliance with official requirements it is claimed to be continuous burning on coke and all smokeless fuel, which complies with the Clean Air Bill, and to be the first solid-fuel appliance to have a built-in fireguard. The construction is entirely of iron castings, vitreous enamelled, and the model is available in a pleasing range of colours. A noteworthy feature of the firegrate is that it consists of individual loose bars and alteration to their spacing to suit coal or coke fuel involves only the insertion of different sets of grooved rests.

New Equipment

Carbon Removal in Re-heating Furnaces

A soot and sludge remover has been acclaimed a success to reduce carbon accumulation on burner nozzles by 70-80 per cent. in re-heating furnaces. The remover—"Xzit S.S.R.," manufactured by Xzit (G.B.), Limited—was used in the forging department of Tubes, Limited, where the accumulation of carbon around the heavy fuel-oil burners in the re-heating furnaces had been causing trouble.

"Xzit S.S.R." was added to the fuel oil over a period of several weeks. There was a reduction of 70-80 per cent. in the accumulation of carbon, resulting in longer life for the brickwork, cleaner burner tips, and improved atomization. This reduction in carbon considerably reduced the time normally required to clean out the furnaces. The tanks and lines were also cleaner, as any sludge present in the fuel oil was brought along to the burners and consumed in the furnace.

New Building Development

A building of unique design covering an area of more than 750,000 sq. ft., with a volumetric capacity of nearly 17,000,000 cub. ft., and constructed in accordance with the new "Metsec" building technique recently developed by Metal Sections, Limited, of Oldbury, a subsidiary of Tube Investments, Limited, has recently been completed in the North of England. The same basic principle of construction is that already widely employed in prefabricating skeleton bodies for buses, coaches and railcars; its spread to buildings has, therefore, been a natural development. In less than 14 months, the building in question was designed, fabricated, delivered to the site and erected on its foundations, the general contractor being Sir Alfred McAlpine & Sons, Limited, which cleared and levelled the virgin site, and laid 15,500 cub. yds. of concrete weighing some 28,000 tons. In this same period, Metal Sections, Limited, produced and manipulated more than 1,400 tons of steelwork, involving over 2,000,000 ft., equivalent to 400 miles of cold-formed sections; in addition to this, some four miles of gutter sections, together with all the necessary fittings, were manufactured and erected.

In construction, the components are unloaded and laid out on the foundation, each leg and rafter unit being then site bolted together at the knee connection. This connection is made by a loose connecting member and 12 high-tensile bolts and nuts per half arch. To make these connections for a complete arch takes 40 min. for a gang of three men with the aid of a mobile crane. The building is erected in frame sections at a speed of about 1,000 sq. ft. per hr. It is estimated that the project will be completed from start to finish in approximately 20 months. When the building has been completed, the sheeters will have used nearly 900,000 sq. ft. of asbestos cement cladding and a similar amount of both lining board and insulation blanket. The accompanying illustration (Fig. 1) shows an interior view of the building, which is being used as a store.

FIG. 1.—*Interior view of "Metsec" prefabricated building, showing steelwork and lining board.*

High Temperature Refractory

Lafarge Aluminous Cement Company, Limited, 73, Brook Street, London, W.1, announce that Secar 250 is now commercially available in Great Britain. This is a white calcium-aluminate hydraulic cement with an alumina content of 70-75 per cent. and with total impurities less than 1 per cent. Refractory concretes or castable mixes incorporating Secar 250 and a refractory aggregate have the normal setting-time and ultra-rapid hardening properties usually associated with Ciment Fondu, but it is claimed they also have a greatly enhanced refractoriness. For example, concretes made with Secar 250 and corundum aggregate can be put into service at temperatures up to 1,800 deg. C. thus substantially increasing the range of refractory castable construction. Secar 250 may also be used with refractory aggregates such as crushed firebrick, sillimanite, chrome and chrome-magnesite. All such concretes can be employed within 24 hours of casting. They do not shrink, and have exceptionally high resistance to thermal shock.

MINOR ALTERATIONS and improvements have been announced to the Bullows PR.303E portable spray-painting plant of which some 5,000 have now been sold in the domestic market. There have been some failures of the bonded-rubber coupling and this has been replaced by a claw-type coupling. The lubrication system is operated by air pressure, and a few cases have occurred where plants have been connected up in such a way that they have operated at a lower pressure than the minimum for safe lubrication. Thus, a minimum-pressure valve has been designed, and is now fitted as standard to all machines. The machine incorporates a Hydrovane compressor, silent in operation, and all moving parts are submerged in an oil bath, so that wear is virtually eliminated. The compressor with its ½-h.p. motor weighs 42 lb.

Iron and Steel Statistics

United Kingdom and Overseas Countries

Valuable additions to information concerning the iron and steel industries in this country and abroad are made by the statistical year books issued by the British Iron and Steel Federation. The latest edition is in two parts, covering in Part I the United Kingdom in 1954, and in Part II overseas countries in 1953, the lag in the latter case being due to the enormous amount of work involved in collecting world statistics in all their detail.

Part I embodies further improvements in scope and presentation compared with previous years. Some of the charts illustrating certain aspects of the industry's structure and development, included in the last edition, have been replaced by charts on other aspects of interest. Two new pages of diagrams have been included in order to illustrate the statistics of steel deliveries by product and industry presented in detail in two of the tables.

Diagrams representing deliveries of each product group, and of all products together, analysed by the main markets for which they are destined, are supplemented by a product analysis of each of the major markets. The idea of these diagrams is to help to make clear the present distribution of finished steel.

To provide additional information in a more useful form than before, two tables on home iron-ore production have been merged, and, for the first time, a table gives particulars of sinter plants. A table dealing with ferro-alloys, unpublished in recent years for security reasons, has reappeared. A new table of scrap ratios in steelmaking analysed by process and district has been added. Introduction of a table on railway rolling stock extends information regarding the steel-consuming industries, while a table on shipbuilding has been improved. Finally, data on the export of certain fabricated steel goods and on the volume and value of UK exports have been adjusted to the new trade classification.

The volume contains over 100 tables, presenting together an exhaustive analysis of the iron and steel industry. Statistical information regarding prices, index numbers, industrial production, motor vehicles, coal-mine supports, and employment, adds to its value. Some 20 tables are devoted to imports and exports.

Part II includes information about 43 overseas countries and contains 437 pages with 283 tables. Part I is priced at 7s. 6d. and Part II at 15s. Copies may be obtained from the British Iron and Steel Federation, Steel House, Tothill Street, Westminster, London, S.W.1.

Services for the Disabled

"Services for the Disabled," issued by the Ministry of Labour and National Service, is the first official book to give a comprehensive account of the work that is being done in the United Kingdom to help disabled persons to overcome their handicaps. It is presented by the Standing Committee on the Rehabilitation and Resettlement of Disabled Persons, and in an introduction, Sir Harold Wiles, who was until recently chairman of the Standing Committee, commends the book to all who are interested in what is being done to overcome the handicap of disablement and who need a handy guide to the many different kinds of service available. The book is published by the Stationery Office (4s. 6d.).

Fairbairn Lawson's New Set-up

Fairbairn Lawson Combe Barbour, Limited, are to close their Belfast textile machinery factory early next year. Manufacture of textile machinery will be concentrated in Leeds and Dundee. The closure is part of the reorganization disclosed recently when it was announced that there would be no dividend on the group's £399,426 ordinary capital, against the 12½ per cent. paid for the past four years. The accounts for the year ended March 31, were expected to show a group trading loss of about £30,000, and it was necessary to provide about £200,000 for stock losses.

A statement issued by the firm recently said: "This particular reorganization is mainly due to two world causes, namely, the decline in the demand for flax and hemp machinery and the necessary arrangement recently concluded for jute machinery to be manufactured under licence in India. Efforts have been made in conjunction with the Ministry of Commerce to find alternative lines, but it has not been found possible to obtain sufficient work of a type which would allow the Belfast factory to run economically. It is therefore proposed to close the company's Belfast factory early next year when the present contracts are completed." The Belfast factory —Falls Foundry—employs about 400 men.

Corrosion- and Heat-resisting S.-g. Cast Iron

The *Nickel Bulletin*, vol. 28, No. 6-7, contains the following abstract on corrosion- and heat-resisting s.-g. iron.*

The material, treated with magnesium as necessary to meet the tensile and microstructural requirements laid down, is required to be within the following limits: Total carbon 2.4-3.0, silicon 2.0-3.2, manganese 0.8-1.6, phosphorus 0.25 max., chromium 1.7-2.4, nickel 18.0-22.0, copper 0.50 max., lead 0.003 max., per cent. Tensile and hardness requirements are prescribed, as determined on test-pieces (of specified form) and on the castings, and it is required that the microstructure shall consist of spheroidal graphite with small amounts of carbide in a matrix of austenite, essentially free from flake graphite. It is also laid down that the parts must be capable of being cooled to −59 deg. C. without the austenite transforming to martensite; parts so cooled, after returning to room temperature, must be sufficiently non-magnetic to prevent a small steel magnet from adhering to the casting.

* Soc. Automotive Engineers: "Alloy Iron Castings, Ductile, Sand, Corrosion- and Heat-resistant." *A.M.S. Specification* 5394, issued March 1, 1955.

Progress of Special Irons

At the centenary congress of the *Société de l'Industrie Minérale* held recently in Paris, Mr. Guy Henon presented a paper on the "Progress of Special Irons and their Uses in the Mining Industry." In it he included the following table:—

Nature of the iron.	Temperature limit of use, deg. C.	Approximate melting point, deg. C.
Ordinary phosphoric iron	300	1,050
Pearlitic iron (non-alloyed)	400	1,150
Grey iron with moderate chrome content and iron carrying manganese	550	1,150
Chrome or manganese white iron	600	1,150
Nickel/chrome iron	600	1,150
Chrome/titanium iron	600	1,150
Silicon or aluminium ferritic iron	650	1,150
Ni-Resist	800	1,150
Chrome, ferritic iron	950	1,300

Spalling of Green-sand Moulds and its Relation to Casting Defects

By H. Pettersson

(*Continued from page* 271)

COMMENTS ON RESULTS

(1) Influence of Gas Pressure

Among the possible causes of the yielding of a mould exposed to thermal shock not only the expansion of the sand but also the gas pressure could be considered to be of great importance.

There are a number of facts which prove that the expansion is the main cause. The great difference between moulds made from quartz sand and other, less expanding, sands, the occurence of a sand rain and the character of the spalling can be mentioned as examples. An opinion, which was earlier generally accepted, however, was that scabs and related defects were caused by the pressure of the gases evolved in the mould when it was rapidly heated by the poured metal. Also now many foundrymen believe that gas pressure is the real cause of scabs or that it at least contributes highly to their formation. The results of this investigation, and also of all others where the factors have been controlled and the occurrences carefully observed, do not support this opinion. From the present investigation the following examples can be elicited. If the quartz sand is exchanged by some other material the spalling resistance is very considerably increased. In a series of tests with sands with an average grain size of 0.3 mm, where only the type of sand and the grain size distribution were varied, the permeability values varied from 20 to 240. In general, the most stable moulds were those with the lowest permeability values and the moulds most liable to spalling were those with the highest values. Moulds dried through storing were no more resistant than fresh moulds with a much higher moisture content. The relation between spalling resistance and moisture content (Fig. 6) shows that if the moisture content is increased above the normal values an increase in spalling resistance rather than a decrease is obtained. The moulds which developed the greatest quantity of gases, *i.e.*, those containing cereals or coal-dust, were also those most resistant to spalling.

It can be shown by calculation that if the water is vaporized from a 0.5-mm thick layer containing 10 per cent. moisture in a second and if all of it passes through a 5 mm thick surface layer of a mould with permeability number of 50 the pressure exerted by the gas is only about 0.15 g per sq. mm. Still this case is much more drastic than normal conditions. If the surface be very dense, the pressure can no doubt be higher, but it is evident that gas pressure in normal cases must have very little influence on the spalling of a mould.

It may be argued that gas will be a much more important factor when scabs are formed at the bottom of a mould cavity when hot metal flows over the mould surface. However the pressure of the gas on the dried and heated surface layer can still not be high in the first few seconds as this layer is then very thin and later when it is thicker the static pressure of the metal will probably be higher than the gas pressure and a solid metal skin also forms which will help to inhibit the spalling. Besides if scabs were formed in such a manner that gas pressure pushed a layer of moulding sand into the metal, then some of the gas must bubble into the metal. In fact a more or less general boiling should occur It is only exceptionally that buckles and scabs are connected with such porosities as would then result.

It is moreover the Author's opinion that the formations of "bottom" buckles or scabs is never started under a layer of molten metal. Observations during casting experiments indicate that the process is the following: The molten metal flows into the mould in one or more streams. Under these streams the adjacent sand expands rapidly and if the pressure is great enough the layer will move outwards, a crack may form and a piece of the layer may be partly or completely detached from the mould by shearing. The cracks will form where the sand is weakest, that is where it is not covered by metal. The pressure of the metal also helps to keep the sand down. After the crack has been formed the further development of a buckle or scab can proceed under molten metal.

(2) Influence of the Thermal Expansion of the Sand

The intimate relation between the failure of the mould wall and the thermal expansion of the sand is well established by the results of the present investigation and earlier by the work sponsored by the American Foundrymen's Society[2] and by investigations made by the staff of the British Cast Iron Research Association [3 4 5]. One of the AFS committees has reported a good correlation between the formation of rat-tails and the relation between the hot compressive strength at 540 or 595 deg. C. and the maximum confined expansion of the sand measured in a quartz tube by shock heating at 815 or 1,480 deg. C.[6]. A combination of a low hot-compressive strength and a small expansion is said to give the best results. Another committee has reported a good correlation betwen the tendency of scab formation and the temperature at which the curve representing maximum strain, *viz.*, temperature for the sand crosses and rises above the curve

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representing the confined expansion, *viz.*, temperature for the sand[7 8]. The lower the temperature is at which the curves coincide, the less the probability of scab formation is said to be. The opinion advocated by the staff of the BCIRA is that the character of the stress-strain relation of the sand in compression is practically all-important, although of course it is considered against the expansion curve (free expansion?) which does not vary much so long as quartz is the chief ingredient[3 4 5]. A slow decrease of the stress after the maximum stress is attained is considered to be the distinctive feature of a sand with which the tendency of scab formation is small. An ingenious equipment has been constructed for the examination of the stress-strain relation under compression at arbitrary temperature.

The confined expansion test used in the U.S.A. as a measure of the expansion tendency of the sand represents a complex of fundamental properties and is apparently not very well understood. On the other hand the test-conditions simulate to a certain degree the conditions in a shock-heated mould. It is not perceivable, however, why there should be a relation between this expansion and the hot compressive-strength, such that the increasing effect of increasing expansion on the tendency of scab formation can be counteracted by a proportionately decreasing hot compressive-strength. It is much easier to understand why there should be a relation betwen the ultimate strain by compression and some expansion characteristic. However the temperature at which the strain curve crosses the expansion curve is reported to have been 830 deg. C. or higher. At these temperatures the sand has already ceased to expand. One would rather believe that the maximum strain at temperatures below 573 deg. C. would be decisive. It is interesting to learn that nevertheless reasonable agreement has been obtained with the results of casting experiments, when sands bonded with fire clay or varying percentages of bentonite were used. The British investigations have not yet advanced so far that it is possible to say how well their hypothesis agrees with actual performance. Anyhow it seems not to be possible to explain from the reported results the difference in spalling behaviour between sands bonded with a kaolinitic clay and sands bonded with bentonite.

The background of the suggested relations between certain physical properties of the moulding sand and its behaviour in a mould with respect to the formation of scabs and related casting defects, is, of course, the fact that normal sand-testing gives no information about this behaviour, which is a very serious limitation. The Author's opinion is that foundrymen have got to learn much more about what happens in the moulds when they are exposed to thermal shocks of different types from the poured metal, before any reliable laboratory tests can be recommended. It is obvious that some high temperature test is necessary and so the fundamental work done in this field, and as yet this has almost exclusively been done in the U.S.A., is very valuable.

What the Author feels as a void in the treatment of the problem so far, is that too little consideration has been devoted to the consequences of the steep temperature gradient prevailing in the mould during pouring. One consequence is that a comparison between the expansion and the capacity of deformation should be made over a range of temperatures and the net effect calculated by integration. Even then the results could be very misleading as in practice a levelling of the theoretical stress distribution will occur. Probably as a result of this dilemma there is no mention of, or an uncertainty, in the American and English literature about what temperature should be chosen for the comparison. Another important consequence of the temperature gradient is that rupture does not occur in the same manner in a mould wall suddenly heated from one side as in a uniformly heated test piece. In fact there are two kinds of rupture which must be considered in the shock-heated mould, namely the one approximately parallel to the mould surface and the one that takes place at an angle to the mould surface. The latter is the one most closely connected with the rupture occurring in compression tests. The former, which seems to take place at the interface between the dried layer next to the surface and the wet sand behind is completely neglected in the above named hypotheses. No distinction at all is made there between the behaviour of dry and green moulds. In a paper where the casting defects caused by the thermal instability of the moulds are discussed, Nicolas[9] suggests that the spalling of green sand mould occurs at the interface between dry and moist sand. No further reference to this important aspect on the problem has been found in the literature.

(3) Aspects of the Process of Spalling

In what follows, the Author will try to outline his conception of how a green sand mould fails and why it fails when it is exposed to the sudden indirect heat from molten metal. The views are based on the observations made during this investigation and the picture given thus applies at first hand to the type of mould and of heating that has normally been used during the investigation. The sand material is supposed to be quartz.

During the first moments of heating only a layer of one or two sand grains' thickness will be affected. The expansion of these sand grains meets little resistance in the direction towards the mould cavity but a great resistance in the other directions. On many sand grains the lateral stresses will impose a resultant stress in the direction out from the mould, and if this stress resultant is greater than the bonding strength, the grains will be squeeezed out from the mould—a sand rain will occur. Due to the release of sand grains, and also to the rearrangement of other sand grains, the lateral stresses are kept within moderate limits. The sand rain will reach its maximum as the surface grains are transformed to the high-temperature modification of quartz.

As the heat penetrates deeper into the mould the distance between the isotherms representing beginning and end of expansion decreases at first. Thus an expanding layer of decreasing thickness moves

inwards followed by a growing layer of practically volume stable sand. At the same time, moisture accumulates in front of the expanding layer in the neighbourhood of the 100 deg. C.-isotherm. (In order not to complicate the picture unnecessarily the lower temperature limit of the expanding layer is put at 100 deg. C. Up to this temperature and even a little further the expansion is also negligible.) As long as the expanding layer has only the thickness of a few sand grains it is not mechanically very stable, the grains are relatively easily rearranged and the lateral stresses can not become very high. As the expanding layer increases in thickness its strength also increases.

At the same time, the exterior hotter layer also becomes stronger and counteracts the movement of sand grains towards the surface. Thus the lateral stresses in the expanding layer will increase. An important consequence of these changes is that, instead of the mainly individual movements of the sand grains in the early stage, there will now be a movement of more coherent layers in the directions where the resistance is smallest. The increase in thickness of the expanding layer, which will follow later, is accompanied by a decrease in the rate of heating. Thus there will be more and more time for the moulding sand to undergo plastic deformation. This will tend to diminish the stresses. Further, as the thickness of the expanding layer increases the gradient of the lateral stresses decreases and at the same time the shear stresses also decrease. The increased thickness and strength of the exterior hot layer may have the effect of subduing the strain of the expanding layer to some extent. In any case the transverse strength of these combined layers is increased. It is then quite natural that there is a critical time of heat exposure. If that time is attained without spalling, it is quite probable that there will be no spalling at all.

The loosening of sand grains at the exposed surface is the first sign of failure. What will happen later is determined by several factors, the most important of which seem to be:—

(*a*) Magnitude of the shear stresses at the interface between dry and moist sand.

(*b*) Relation between shear stresses and strain at this interface.

(*c*) Relation between strain and cohesion at this interface.

(*d*) Magnitude of the tensile stresses (caused by the gravity and other factors) which tend to pull the surface layer from the moist part of the mould.

(*e*) Magnitude and distribution (especially in the directions parallel to the mould surface) of the lateral compression stresses promoted by the heat expansion of the sand.

(*f*) The relation between compression stresses and deformation (or rather inhibited expansion) in the expanding layer at different temperatures. Especially it is of interest to know the maximum strain before a pronounced breaking occurs or before the stress decreases much below the maximum stress.

(*g*) The relation between stress and strain in the exterior layer where the expansion of the sand has already ceased.

(*h*) The heat conductivity of the mould.

Para (*a*) is intimately related with (*e*) and also with (*g*).

There is a great complexity of properties which it is difficult to survey. The most important properties of a green mould with high spalling resistance probably are: (α) That it has a high shear strength and good cohesion at the interface between the dried surface layer and the moist sand behind; and (β) that the layer where the sand grains are expanding can stand a great deformation before it breaks.

It is in fact very dangerous to speak of the formation of the transverse and the parallel ruptures of a layer as separate processes. They are intimately interwoven and exert a mutual influence on each other. It is true that it is possible to imagine a separate parallel rupture, a partial disconnection and outward bulging of a layer without a crack, and such a performance has been observed. It is, however, not common and until there is a transverse break there will not be any of the casting defects mentioned here. Anyhow the loosening of a layer, facilitates the formation of transverse cracks—the difference in spalling resistance between dry and green moulds is explained by the ease with which a layer slips and is disconnected in a green mould. The transverse breaks, cannot develop to any high degree until the layer has begun to slip; on the other hand, this sideward movement is immediately and most considerably increased as soon as a crack has formed and during the slip the layer is released from the mould. Because of the shear stresses the transverse breaks will aid to pull the layer away from the rest of the mould. If these facts are kept in mind it may be permissible to consider the two types of failure separately as, in the Author's opinion, the process is then better understood.

The sideward movement explains the influence of the size of the heated mould surface. If there were no such movement, the stresses and strains would be independent of the size of the mould. In practice an adjacent heated surface layer can expand to some extent towards a less heated or weaker part. The distance of expansion before a break occurs is determined by the stress-strain relation in the yielding part. When the ultimate stress is attained there, a local compression or shear followed by a rupture will occur in a narrow zone. The extension of the expanding layer during the process of rupture is thus approximately independent of the size of the mould. The relative real lateral expansion of the heated layer, however, is inversely proportionate to the linear size of the heated surface. The real expansion corresponds to an equivalent decrease of the confinement of the expansion (*i.e.*, the compression) and thus a decrease of the stresses in the expanding layer. At a given time of heating the compressive strain should be the smaller, the smaller the heated surface is—all other conditions being the same. Another somewhat oversimplified

way of expressing the same thing is the following—a certain distance of sideward movement is necessary before a rupture occurs. The relative expansion necessary for this extension of a layer is greater the smaller the layer. It is then natural that there is a critical size of the heated mould surface (when the other mould properties and the heating conditions are given) such that a mould of this or a smaller size can stand the heat effect practically any time without spalling. The experiments indicate that the spalling resistance decreases rapidly at first and then successively slower as the size of the mould is increased above the critical size. This is what could be expected according to the above considerations although it is not likely that they give the whole story.

Taking into consideration the complicated combination of stresses and strains in the heated surface layer it is not surprising that moulds can spall in several ways. If the dried surface layer breaks in a brittle manner already at a very small strain (confinement of the expansion) layers of very small size are peeled off, and the spalling resistance is small. As the brittleness of the surface layer decreases, the spalled pieces become larger. As a rule the spalling resistance increases at the same time. However, even if the whole heat exposed layer is peeled off as a unit, the spalling resistance can be mediocre. In such cases the cohesion between the dried surface layer and the wet sand beneath is obviously bad. In some moulds which have been so resistant that no spalling has occurred, it has been observed that a fairly thick layer (about 10 mm, $\frac{3}{8}$ in.) has been almost separated from the rest of the mould. The cohesion, however, was still very good. In this case the compressive strength of the expanding layer must have been high and the disposition to crack formation small.

The "snow-flake" type of spalling that may occur, especially when the sand is very fine grained and the moisture content low or moderate, resembles to a certain degree the spalling that was often obtained with ball clay as the only binder. In both cases the released pieces were small. The differences are that in the "snow-flake" process the flakes have an irregular thickness, they often have approximately the shape of a concave-convex lens, and that the "snow-flake" process is much slower than the other process. The thickness at the centre of the flakes indicates that they were formed by a shear process started at the level where the quartz was being transformed. The principal reason for this must be that in the moulds where the small irregular flakes are formed, the transition region between dried and undried sand is not particularly weak. A shrinkage action at the mould surface, caused by the sintering of the surface grains, also seems to help to free the flakes. As the sand is generally very fine-grained, when this type of spalling occurs, it sinters comparatively easily and this tendency may be added to by the relatively high surface-temperature that is to be expected with such sands.

Another type of yield is the one obtained, when the moulds are very weak, *e.g.*, owing to very loose ramming or very coarse-grained sand with a narrow grain distribution. This type which is here called sand-fall is characterized by the sudden falling of a great part of the exposed half-mould. The explanation ought to be that owing to the weakness of the mould the relatively small shear stresses that arise at the depth where the rupture occurs are sufficient, when they are added to the tensile stresses existing there because of the gravity, to bring about the rupture.

(4) Rate of Heating

It is natural that a slowly heated mould resists the heat effect better than a more rapidly heated mould as the temperature gradient, and likewise the stress gradients, will be small in the slowly heated mould. As the rise of temperature is slow, the sand grains will also have more time to occupy stress releasing positions and there will be more time for the interstitial material to be plastically deformed and both these circumstances tend to decrease the stresses.

It is not so obvious why the resistance increases with increasing rate of heating above a certain high rate. There are, however, acceptable explanations. If the rate of heating be very high the expanding layer, longer than usual, will be very thin and therefore a relatively great part of the expansion work will be a transverse (outward) movement of sand grains and thus the lateral stresses will not be very high. Of course the thickness of the expanding layer will gradually increase and then also the lateral stresses. The exterior layer, where the sand has already ceased to expand is thicker, however, when the heating rate is high, than when it is low when the thickness of the expanding layer is the same and, therefore, when the stresses would normally be high enough to produce rupture, the thickness of the two attached layers may be great enough to resist the stresses from the expanding layer without rupture. From the results of the experiments it is also clear that a slight sintering can improve the strength properties of the ultimate surface layer. That is another, and perhaps the most important, reason why the resistance can increase with increasing heating rate. The effect of sintering has been established not only by the direct results with quartz sands of different sintering points, but also by the indirect results with a quartz sand that sintered at low temperatures, which was tested with and without the admixture of a coal-dust with low gas content. The coal-dust decreased the sintering tendency of the sand and also decreased the spalling resistance of the mould.

Another circumstance, that should be considered in this context, is that, particularly with cast iron, the heat emission may be lower at some high temperature, when there is no slag film, than at a lower temperature when there is a slag film. The shape of curve (*b*) in Fig. 4 is probably explained by the difference in heat emissivity.

(5) Sand Material, Grain Size and Grain Distribution

The results with various materials other than quartz are consistent with the expansion curves, which is unusually unfavourable for quartz. The most important reason why the spalling resistance increases with increasing grain size probably is that the temperature gradient becomes smaller when the grain size increases, a consequence of the increasing thermal conductivity. It would also be possible that the heat shock is reduced when the sand grains are big, as the rise of temperature must be slower at the centre of the grains than at the surface. An approximate calculation shows, however, that a grain of 2 mm diameter, the surface of which is suddenly heated to 600 deg. C., will have a centre temperature of 550 deg. C. after 0.4 sec. This delay is not very great and although the lag decreases very rapidly with decreasing grain size it seems probable that the effect of the temperature lag in the grains is small. As the temperature gradient is steep there must, however, be a considerable difference in temperature between the grain surface that is next to the mould surface and the opposite surface when the grains are big. It is not easy to foresee, however, the consequences that this fact may have on the stresses in the mould.

Another difference between fine and coarse sands lies in the distribution of the binders and admixtures. Over a given distance the integrated thickness of the individual layers is at least approximately the same in all cases if the percentage of the interstitial materials is the same. However as the grain surfaces are irregular and the individual layers are thinner when the grain size is small it is possible that the distance available for plastic deformation will be smaller when the sand grains are fine. The increasing gas pressure, that is combined with decreasing grain size, may have a small but in no way decisive effect.

The fact that the spalling resistance increases with increasing wideness of the grain size distribution may have several causes. The heat conductivity is increased and thereby the temperature gradient is reduced, the grains at the same average distance from the mould surface do not expand simultaneously and the mobility of the grains may be increased when many grain sizes are mixed. The increased mobility of the sand grains, and also other factors, increase the maximum strain. The strength is also increased but this is probably valuable only in connection with the transition zone between dried and moist sand. If the strength in this zone be increased, the spalling resistance should be increased. It is in fact to be expected that the resistance against slip in this zone should be greater when the sand grains have a wide size-distribution than if they are all of the same size.

The influence of the sintering tendency of the granular material has already been mentioned. A low sintering temperature may evidently be favourable. This effect however, is more or less completely suppressed by the addition of organic compounds.

(6) Quality and Quantity of Binder

If the properties of clays that have given good results are compared with those of clays that have given poor results, it is found that the best clays give much higher dry and hot strength and have a much greater swelling capacity (gelling index) than the poor clays. If natural sodium bentonite is compared with ball clay as typical examples of a good and a less good clay, the following conclusions can be made. In moulds bonded with Na-bentonite the spalled layers are big, while in moulds bonded with ball clay the surface layer is cracked in small pieces in a brittle manner. This is the case even if the content of ball clay is so much greater than the bentonite content that the dry or hot strength is about the same in the two types of moulds. This indicates that the important difference is that the bentonite makes the mould more elastic-plastic than the ball clay. It is also to be expected that the great swelling capacity of the sodium bentonite should give the mould a relatively high maximum strain by compression as the interstices between the sand grains should be filled with a relatively low percentage of solid bond. It is remarkable then that there is no real support of this supposition in the literature. The results of the experiments with separate layers of different sands also indicate that the strength properties of the region where dried sand is in contact with moist sand become better when the bond is bentonite than when it is ball clay.

That an increasing clay content in the mould increases its spalling resistance is probably explained by the thereby increased capacity of the sand of being compressed without bursting—greater maximum strain. It is however of a certain interest that the simultaneously increased dry and hot strength of the expanding layer does not increase the tendency to spall as it is sometimes asserted in literature that a high strength is dangerous. This remark also applies to the difference between sodium bentonite and other clays.

(7) Moisture Content

The relation between the moisture content of the sand as mixed and the spalling resistance of the moulds, which was obtained by the experiments, is not so easy to explain. The surprisingly great resistance that was obtained at extremely low moisture contents, especially with swelling bentonites, but also with ball clay, though then at still lower moisture contents, seems to be connected with the very stiff consistency of the clay at those low moisture contents. The clay in this case does not act so much as a bond as a material that yields when the sand expands. The cushioning effect would also explain the great difference in results with the highly swelling bentonites and ball clay. It is of interest in this connection that when the swelling capacity of the bentonite was destroyed by hydrochloric acid a relation between spalling resistance and moisture content similar to that with ball clay was obtained.

The fact that the spalling resistance decreases when the moisture content is increased to normal

values is probably due to the then increased strength of the moulding sand which confines the mobility of the sand grains and causes the stresses to increase without an equivalent increase in maximum strain. That a further increase in moisture content does not decrease the spalling resistance, but rather increases it, might be explained by the somewhat denser packing of the sand that is obtained at high moisture contents, which may increase the shear strength at the interface between the drier and the moist sand.

(8) Additions of Coal-dust, Cereals and Sugar

The beneficial effect of coal dust in moulding sands is considered to be that the material is plastic, has a cushioning effect, particularly at the temperatures where the sand expands. This view in the Author's opinion lacks in distinction. It is hardly pure incidence that such substances as pitch, cereal flour, dextrin and sugar have a similar effect as coal-dust. What all these substances have in common is that at the temperatures existing in the expanding layer they function at least for some time as viscous binders. They also all give off distillation products at high temperatures. The poor result with coal-dust with "low gas content" confirm that it is the distillation products, probably the tar and pitch, that are the valuable constituents in coal dust.

The results of the experiments with separate layers indicate that it is not only the properties of the expanding layer that become favourable by the addition of these organic substances but also the properties at the interface between dried and moist sand. These experiments also indicated that the substances in this group could have a favourable influence even if only distillation products arrived at the expanding layer.

(9) Other Additions

The addition of substances insoluble in water—1 or 2 per cent. iron oxide or chalk powder, 5 per cent. dead-burnt bentonite, 6 per cent. lamp black or up to 10 per cent. silica flour—to a mixture of sand, bentonite and water made but little difference. Sometimes the resistance was a little better, sometimes a little worse than without the additions. This is not very surprising, though the opinion is often heard that "dust," that does not act as a binder, has an unfavourable influence. In fact a negative influence could be expected, since the fine particles will decrease the amount of binder available to the sand grains. If the mixing operation is not satisfactory this effect can certainly be a serious disadvantage. With too much silica flour it is also possible that the expansion shock could be more powerful than in other moulds. On the other hand, if the particles are well distributed, and the percentage not too high, they should make the moulds more plastic. In American literature, the statement is often seen that silica flour increases the tendency of the formation of scabs and related casting defects, and that the reason should be that silica flour increases the hot strength of the sand. The explanation can hardly be true as no particular high-temperature effect of the silica flour exists at the relatively low temperatures in the expanding layer and an increase in strength in the hottest layer where the sand does no longer expand should rather be useful. Besides the whole conception that a high strength in itself should be detrimental has found no support in this investigation.

Water soluble substances with acid reaction, like hydrochloric acid, boric acid and oxalic acid definitely decreased the spalling resistance when added to sand mixtures bonded with sodium bentonite. This effect seems to be connected with the fact that the swelling capacity of the bentonite is strongly reduced if the pH of the liquid is lowered under a certain value.

Sulphite lye also decreased the spalling resistance of bentonite bonded moulds. In this case the relation between this effect and the swelling of the bentonite is not so obvious. Experiments showed that the two qualities of sulphite lye used in the mould, reduced the viscosity of an originally fairly stiff mixture of bentonite and water considerably, though only when the proportion between lye and bentonite was small, much smaller than in the moulds. When the proportion was higher the viscosity increased again and was soon higher than initially. The increase in viscosity may be caused by the swelling of the sulphite lye itself. In contrast to this behaviour, the spalling resistance decreased continuously with increasing lye content in the mould. It is evident that something "detrimental" happens to the bentonite. It is true that both qualities used showed acidic reaction in water solution, but even when neutralized with soda, the lye had no positive effect despite the sugar content. It is possible that the lye in itself reduces the plasticity of the moulds at high temperatures.

(10) Storing of Green- and Dry-sand Moulds

The experiments made with stoved moulds in this investigation have shown a spalling resistance much superior to that of corresponding green moulds. Also moulds made from moulding sand of low moisture content have shown good resistance. It is then indeed surprising that moulds that have dried during storing so that the moisture content has decreased from the original 2.8 per cent. to about 0.5 per cent., have practically the same spalling resistance as fresh moulds. This result, however, is in good agreement with the circumstance that oven-dried moulds which were stored until they picked up a moisture content of about 0.4 per cent. also behaved as undried moulds. It is clear that it does not matter very much what the moisture content is when the mould is used, with the exception of very low moisture content. The important thing is what the moisture content is when the mould is made. It is also this latter content that decides the structure of the mould. The most important influence that a change of the moisture content after the mould has been made can have on the spalling resistance, is that it changes the differences in moisture content at the region where the surface

layer, that has been dried by the heat from the molten metal, is in contact with the still not dried moulding sand. From the results it is evident that it is not possible, by storing in normal atmosphere, to get down to such low moisture contents, that the strength properties at this region are considerably changed. Judging from the results with the stored moulds, there is a critical value of the moisture content not much below 0.4 per cent. that marks the difference between dry and green moulds. This does not mean, however, that there would be no difference between moulds with 0.3 per cent. and moulds with 0.0 per cent. but only that the spalling resistance seems to increase rapidly when the moisture content is lowered to or below the former value.

(11) Ramming Density (Mould Hardness)

The fact that a minimum of spalling resistance was obtained at a certain ramming intensity indicates that at least two factors are influenced by the ramming in such a way that the changes have the opposite effect on the resistance. When the ramming intensity is increased the sand grains are gradually packed closer. Thereby the chance of a grain to expand without forcing other grains out of their place (or be forced away itself) is decreased. Thereby also the resistance to spalling decreases. It would be natural if this detrimental effect of the denser packing would cause the spalling resistance to decrease continuously and even at a successively growing rate. The results of the experiments however was that after a range of mould hardness, within which the spalling resistance decreased rapidly with increased hardness, the decrease slowly ceased and was even changed to a slow increase. The most likely explanation of this behaviour is that it is caused by the increased strength of the mould. Whether it is the increased rigidity of the expanding and the hottest layer or the increased resistance against slip in the transition region between dry and moist sand, that is decisive, can not be settled by the results of the experiments.

Another important question in connection with ramming is the effect of uneven ramming on the spalling resistance. Uneven mould hardness must provoke a tendency of harder layers to move towards adjacent softer layers during the heat exposure. Such movements should limit the compression stresses and strains in the hard regions and increase them in the weaker regions. The effect of the movements on the spalling resistance depends on several factors, some of which will be mentioned later.

If the stresses at completely confined expansion in the harder regions are not greater than the maximum compression stresses in the looser regions there should be no failure (Fig. 9). This case corresponds to very loose ramming. The more the stresses at completely confined expansion in the hard regions exceed the maximum stresses in the less hard regions, the greater the chance is that the weaker regions will break. As the maximum strain is normally greater in the less hard regions there need, however, not be any break, and the chance of breaking should also be greater the larger the hard regions are in comparison with the less hard regions. If the medium hardness is taken as a standard of comparison the relation of the sizes is however eliminated from the comparison. The argument is best illustrated by an example. In Fig. 9, the two curves represent the integrated stress strain relation in two adjoining regions (*in situ*, not as free layers) one region being harder rammed than the other. For the sake of simplicity the areas of the regions are assumed to be equal. If a break occurs at a compressive strain that is less than the average OC′ of the strains necessary to break the individual layers, it is assumed that the hardness difference makes the mould more inclined to spalling. If the acceleration stresses are left out of the discussion the stresses in the harder layer should not exceed the maximum stresses in the looser layer, *i.e.*, they should be = OD″ = OB″ and the strain = OD′. The average strain when the looser layer breaks = OE′ = OD′ + OB′ = OD′ + DB′ which is smaller than $OC' = OA' + \frac{A'B'}{2}$ In this example the break thus would occur at a much smaller strain than it should have done if the ramming had been of a uniform and intermediate hardness. It is obvious that the result of this very schematic reasoning depends on the shape of the curves. The possible weak point, however, is not to be found in the shape of the curves as all pairs of natural curves give the same result.

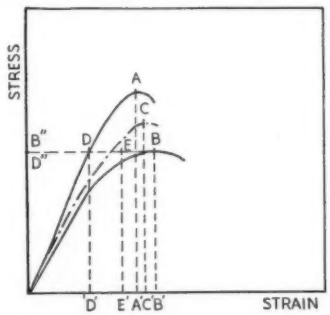

FIG. 9.—*Hypothetic stress/strain curves for (A) a hard-rammed and (B) a less-hard-rammed part of the mould; curve (C) is the average.*

The harder a mould is rammed, the less the differences in hardness becomes. According to the above, this change is also a possible explanation of why very hard ramming makes the moulds less inclined to spalling than somewhat looser rammed moulds despite the decreased space for expansion of the sand grains.

The very rapid increase of the spalling resistance that was obtained when the hardness was decreased under normal values was interrupted at a certain hardness limit when the moulds began to "collapse" instead of the normal more superficial

flaking. The cause of this collapse has already been discussed (Paragraph 3).

(12) Relation between Spalling Resistance and Test Values Obtained by Normal Sand Testing

The only ordinary sand test which has been found to have some relation with the spalling resistance is the bulk density of the dry moulding sand. This relation however is not consequent. Sometimes a decreasing bulk density corresponds to an increasing resistance. In general there is a relation of this kind when the hardness of the moulds is varied, though, of course, this comparison is outside the scope of ordinary sand testing. When the moisture content of a moulding sand was varied, the bulk density increased and decreased at the same time as the spalling resistance. When moulding sands with different base sands but otherwise of similar composition are compared a clear tendency has been observed of an increased spalling resistance with increased bulk density. Thus the relation between bulk density and spalling resistance is often direct and not inverse as one would expect. This may be a reflexion of the increased flowability that is often connected with an increased density, but may also indicate that a natural close packing makes the moulds mechanically more stable.

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[5] R. G. Godding, R. Rew, "Behaviour of Sand Mixtures under Load at Room and Elevated Temperatures," B.C.I.R.A. *J.* of Res. and Dev. **5** : 5, 1954, 278-295.

[6] Final Report of A.F.S. committee on Physical Properties of Iron Foundry Moulding Materials at Elevated Temperatures: Causes of Rat-tail Casting Defects. *Trans.* A.F.S. **57**, 1949, 526-534.

[7] R. G. Thorpe, A. E. Riccards, P. L. Widener, P. E. Kyle, "Investigation of the Physical Properties of Steel Sands at Elevated Temperatures." *Trans.* A.F.S. **60**, 1952, 127-210.

[8] R. G. Thorpe, H. Robinson, P. J. Wisniewski, P. E. Kyle, Twelfth Annual Report on the Investigation of the Properties of Steel Sands at Elevated Temperatures. *Trans.* A.F.S. **61**, 1953, 96-106.

[9] P. Nicolas, "Behaviour of Moulding Sand at High Temperature," *Giesserei*, **41** : 13, 1954, 333-338.

DISCUSSION

[At the Congress, this Paper was presented by the Author in person.]

MR. W. B. PARKES, opening the discussion, said he was doubtful as to how far spalling was due to an increase in dry-strength, since no increase occurred.

With regard to test castings, he would not disagree with the Author at all; for two people working with totally different materials the results were surprisingly in agreement.

MR. H. HAYNES said, as far as spalling was concerned, he had no great difficulties in this respect when green-sand moulding flywheels of 4 tons, and in one day one man could make in green-sand a casting up to 20 cwt. with no spalling whatever. The technique of the foundry was governed by years of experience but the essence of testing was the feel of the sand, which he claimed could not be explained at a conference or put on paper, because a skilled moulder could tell from the feel of his sand whether he was going to have spalling or not. The more moulders could be encouraged to take an interest in the feel of the sand the better it would be. He had recently written a paper entitled "Is Green-sand Moulding Deteriorating?", which he hoped would be a challenge to all foundrymen. His own view was that it was deteriorating because sharp, clean castings used to be produced by green-sand whereas to-day they were not.

MR. J. M. MIDDLETON (British Steel Castings Research Association) said that he was very interested in the statement on page 5 of the preprint of the Paper which said: "Further, the surface temperature increases faster in the 'green' mould than in the dried mould." He had determined metal/mould interface temperatures on both sands and found that the temperature at the interface was similar for both types of sand.

MR. PETTERSSON, in reply, said in fact he had been a little surprised himself at the results given in the Paper, but he believed in them, though the measurements should have been repeated more often. Possibly the reason why the previous speaker did not get any difference was that he measured the temperature when metal was in contact with the sand, whereas in his own case it was quite different—the sand was just heated by radiation.

Influence of Moulding Technique

MR. E. LONGDEN (past-president) said some other very important factors beside the quality of sands were being lost sight of, *i.e.*, the general moulding technique. Large numbers of castings had been made in green-sand and very successfully, too, long before the period of imposing special sand controls. The manner in which the metal entered the mould and the arrangement and control of riser openings were very important matters in the manufacture of medium and large castings. With a large upper mould surface area exposed to rising metal and the riser openings free to the outside atmosphere, the gases generated on this upper surface would flow into the mould cavity and rush out of the risers, very often violently, drawing portions of the top mould-surface downwards. The sealing of the riser tops would put the mould atmosphere under compression and force gases to pass out through the sand top and help to prevent spalling and "drawing-in" of the top mould-surface.

MR. PETTERSSON said naturally he agreed that the technique of pouring was at least as important as the moulding materials, but his investigations had been limited to the moulds—the other side should be left to some other investigator.

On the motion of the CHAIRMAN a very hearty vote of thanks was accorded to Mr. Pettersson for his presentation of the Paper.

Author's Written Comment

After receipt of the transcript of the discussion, the Author elaborated his verbal replies in the following terms:—

Mr. Parkes, when he said that there was no meaning in discussing the effect of an increase in dry- (not) strength, probably had in mind the results obtained with di-electrically-heated test-specimens at the British Cast Iron Research Association. According to these there was no increase in strength when the temperature increased rapidly. In his Paper he had mostly mentioned the effect of increasing dry- and hot-strength when different moulding sands were under comparison, for instance in discussing the effect of different binders and percentages of binders. In this case, of course, different dry- and hot-strength values would result, and he had pointed out that there was no indication that a high dry- and hot-strength had in itself a negative influence on the spalling resistance. In fact the effect in most cases was positive.

The influence of temperature on the strength of the sand was mentioned in the discussion of the mechanism of spalling. It was suggested that the strength of the surface layer where the sand was hotter than 573 deg. C., and had already been transformed, was stronger than it would have been at lower temperatures and that this increase in strength might make the sand more resistant against thermal shock than it would have been without that temperature effect. There was, however, in the results of the investigation, nothing that indicated that differences in this temperature effect played any important rôle in the spalling resistance of normal moulding sands. This was not surprising, as the properties of the expanding sand-layer with temperatures below 573 deg. C., should in all probability dominate the behaviour of the sand.

Effect of Temperature Differential

It was also mentioned in the Paper that uneven heating of a mould surface might lead to an expansion of hotter parts towards cooler parts and eventually to a rupture in a cooler region. This suggestion was founded on repeated observation and the conclusion drawn, that the cooler parts were weaker than the hotter parts, seemed to be logical.

Although it was probably not of vital importance for the theories of the spalling mechanism of sand moulds, this question of the temperature dependence was perhaps worth some discussion. In all high-temperature tests made with the ordinary methods, *i.e.*, with slow heating, a remarkable strength increase had been observed in clay-bonded sands at high temperatures, with a maximum at some temperature between 900 and 1,000 deg. C. With the BCIRA equipment, using rapid di-electric heating, no increase in strength was observed at high temperatures. One must then ask which of these methods gave the true or best picture of what happened in actual moulds. Mr. Parkes had argued that rapid heating obtained with di-electric heating was more similar to the rapid heating of a mould during pouring and said that the strength would increase only after a long heating time. This might be correct, but it must not be forgotten that di-electric heating was not of the same nature as ordinary heating. While with ordinary heating heat moved rather slowly from the surface to the interior, with di-electric heating the large-scale heat distribution was much more even but in fact there was a great number of small-scale temperature gradients. It was possible that in the first stages of heating, the temperature differences between clay and sand grains might be quite large.

The Author made some direct observations pertaining to this question during this investigation. Moulds which had been exposed to the heat from the molten-metal surface for two minutes or more were often tested immediately afterwards by scratching and poking. The heated mould parts always proved to be much stronger than dry moulds at room temperatures. It was true, however, that two or three minutes was not a very short heating time.

The Author wrote that he wished to stress that, like Mr. Parkes, he believed that a mould could have a good spalling resistance only if its toughness or deformability were high. The results of his investigation, however, indicated that generally a high strength was combined with a fairly high deformability. On the other hand, moulds with low strength might have very good deformation properties and very good spalling resistance.

In reply to Mr. Haynes, the Author said he considered that the " feel " of the sand might tell at least as much as ordinary sand tests about spalling properties. This did not mean that the method of testing by feel was satisfactory, but only that the laboratory tests were very unsatisfactory.

Modern Materials

A special conference on " Modern Materials " organized by the Sheet and Strip Metal Users' Technical Association, and postponed from June owing to the rail strike, will be held at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2, on October 10 and 11. Papers include:—" S.-g. Cast Iron as a Material for Press Tools " by Dr. A. B. Everest (Mond Nickel Company, Limited) and " Aluminium-Bronze as a Material for Press Tools " by S. C. Jones (N. C. Ashton, Limited). Further information may be obtained from the Association secretary, at John Adam House, John Adam Street, London, W.C.2.

UK Production Rises

Between the beginning of 1946 and the end of 1954 the volume of output in Britain rose by 27 per cent. and personal incomes as a whole increased by 65 per cent. These figures are contained in a Blue Book published last week by the Central Statistical Office, which also shows that wages in this period increased by 89 per cent., salaries by 90 per cent., income from rent, dividends, and interest by 30 per cent., and income from self-employment by 43 per cent.

The total output of goods and services rose from £9,702,000,000 in 1946 to £12,214,000,000 last year. Manufacturing, mining, building, and gas, electricity, and water accounted for two thirds of this increase.

Monopolies Commission's Report on Copper Semi's*

The Monopolies Commission's Report on the "Supply and Exports of certain Semi-manufactures of Copper and Copper-based Alloys" has now been published. The report covers six main wrought forms of copper and copper alloys—plate, sheet, strip, rods, wires and tubes. These semi-manufactures are supplied to many industries for further fabrication or incorporation in other products. There are about 140 manufacturers of which 70, accounting for more than 75 per cent. of the total production, belong to one or more of twelve trade associations. Most of the associations are members of the British Non-Ferrous Metals Federation.

The Commission have found that conditions to which the Monopolies and Restrictive Practices (Inquiry and Control) Act, 1948, applies prevail as respects the supply in the United Kingdom of the goods under reference, and as regards exports from the United Kingdom, because the 70 makers who are members of the associations produce more than a third of the total supplied, and are parties to restrictive practices affecting both the home and export trade.

The principal arrangements found by the Commission to restrict competition in the home market are minimum price agreements and certain supporting arrangements, including the observance of uniform terms and conditions of trading and the granting of aggregated quantity rebates or "loyalty discounts." As to exports, the Federation and two export groups are parties to the "Lausanne Agreement," an international agreement concluded in 1946, which requires signatory manufacturers to observe each other's home trade prices in each other's domestic markets and (with exceptions for certain products) an agreed price list in most other markets. There are also agreements requiring members of the federated associations and the export groups to charge common minimum prices for exports.

The Commission's principal conclusions and recommendations are as follows:—

(1) The effect of the minimum price arrangements is to keep the level of costs and prices higher than it would be under price competition. The Commission consider that arrangements for fixing common minimum prices in this industry are, and may be expected to be, against the public interest and should, therefore, be abrogated.

(2) Many of the other common trading arrangements are ancillary to the common minimum price system, which the Commission find to be against the public interest, and should therefore also be discontinued. The Commission emphasize that it is the agreement among a number of manufacturers which they find to be against the public interest; they express no opinion about the policy which individual manufacturers might find it expedient to pursue independently.

(3) The Commission consider that both the loyalty and aggregated quantity rebates impede access to the market by independent producers and that these arrangements should be brought to an end.

(4) The Commission consider that the international arrangements should be looked at primarily for their effect on home prices since the industry's contribution to the balance of payments arises mainly from its position as supplier to a great variety of export industries. The intention and effect of the arrangements has been, and is likely to be, to keep home prices up; and this outweighs any possible advantage they may have for direct exports. United Kingdom manufacturers should, therefore, withdraw from the arrangements.

(*Concluded at the foot of col. 2*)

(5) There is no clear evidence as to the effect of the agreements between United Kingdom manufacturers themselves on minimum prices for exports. But if these arrangements are not abandoned as a result of the abolition of common minimum prices in the home market, the Commission consider that their effect should be further examined in two or three years' time.

*The Report is obtainable from HM Stationery Office, Kingsway, London, W.C.2, and branches. Price 7s. 6d. E

Industry Consumes More Gas

Sales of gas in the year ended March 31 were 4¼ per cent. higher than in the previous year, according to an announcement by the Gas Council. The increase was especially marked in industrial sales which were up by 9 per cent. Sales to domestic consumers were 2 per cent. higher and commercial and other sales were over 6 per cent. higher. Preliminary indications for the April-June quarter show a further increase of about 4 per cent. over the corresponding period of last year.

The increased sales of gas were met mainly by increasing the production of water gas, which requires no coal. Production of coal gas increased by 1.6 per cent., and the quantity of coal used by 1.3 per cent., but water-gas production increased by 20 per cent., and the use of oil in producing water gas by 24½ per cent. The quantity of gas purchased from coke ovens and oil refineries went up by nearly 7½ per cent.

The council's statement shows that production of gas coke during the year increased by 0.5 per cent. compared with the previous year. Sales of coke by the industry were 5 per cent. higher than in the previous year and provisional statistics for April to June this year show a further increase of 8 per cent. compared with the corresponding period of the previous year. New gas-making capacity to a total of 137,000,000 cub. ft. per day was completed and brought into operation during the year.

New Titanium Alloy Plant

Early in 1956 a new melting plant for the quantity production of titanium alloy is to come into operation at the works of William Jessop & Sons, Limited, Sheffield. The new equipment, developed from a pilot plant capable of melting 6-in. dia. ingots weighing up to 40 lb., is the result of an exchange of ideas with leading titanium manufacturers in the United States.

Initial output of the new plant will be at the rate of about 350 tons of ingots a year, but, as uses and applications for titanium are likely to increase, provision has been made for extensions. Ingots up to 300 lb. will be produced with diameters of 12 in., while those between 300 and 2,000 lb. will have diameters of 20 in.

The various grades of titanium to be produced will be marketed under the trade name "Hylite" and will be available as hand forgings, drop forgings, drop stampings, rolled or hammered bar, ingots, and billets for forging. Plans are also in hand for producing sheet, strip, wire, and tubing.

Italian Iron and Steel Output

Production of iron and steel in Italy in the first half of 1955 is reported from Milan as follows, in metric tons, figures for the first six months of 1954 in brackets:—Pig-iron, 786,570 (600,332); ferro-alloys, 51,451 (43,099); crude steel, 2,641,101 (1,999,233), of which open-hearth 1,491,591 (1,034,703), electric 959,437 (803,524), basic Bessemer 190,073 (161,006); hot-rolled products, 1,974,064 (1,456,620).

News in Brief

THE OFFICES of W. T. Glover & Company, Limited, wire and cable makers, at Trafford Park, Manchester, are to be extended.

HEAD, WRIGHTSON & COMPANY, LIMITED, announce that the address of their Sheffield office is now 46, Rutland Park, Sheffield, 10.

THE INSTITUTION OF MINING AND METALLURGY has changed its address to 44, Portland Place, London, W.1 (telephone: LANgham 3802).

BRITISH RAILWAYS have placed a contract with Steels Engineering Products, Limited, Sunderland, for the supply and delivery of seven cranes.

ON SATURDAY, September 3, over 90 per cent. of the employees of Goodwin Barsby & Company, Limited, enjoyed a works outing to Skegness.

APPROVAL has been given to plans for a workshop in Park Road, Gateshead, for Clarke Chapman & Company, Limited, engineers, boilermakers, etc.

MANGANESE-ORE OUTPUT in Portugal declined from 12,546 metric tons in 1953 to 9,590 tons in 1954. Exports decreased from 14,170 tons to 3,500 tons.

FIRE DAMAGED the patternshop of Coats Horse Shoe Foundry, Coatbridge (Lanarkshire), on August 26. The foundry is owned by Bairds & Scottish Steel, Limited.

USINES RENAULT, of Billancourt, near Paris, are installing two shell-blowing core machines, stated to be capable of turning out completed cores in 30 to 50 seconds.

THE ADDRESS of the United Kingdom Trade Commissioner's office in Toronto, Canada, is now:—119, Adelaide Street West, Toronto, Canada. (Telegraphic address: Toroncom Toronto.)

AN ORDER covering 20 main-line, 1,500-h.p. diesel-electric locomotives for the Malayan railways has been received by the English Electric Company, Limited. The contract is worth about £1,500,000.

THIRTY BOYS from public and secondary grammar schools have started a week's summer school at the aero-engine factory of Rolls-Royce, Limited, at Derby. The school has been arranged for boys in search of a career.

THE SWEDISH RIKSDAG has sanctioned the purchase by the State of the Grängesberg Company's shareholdings in the Luossavaara Kiirunavaara iron mines, as a result of which the latter will become entirely State-owned.

THE WORKS of the Derbyshire Silica Firebrick Company, Limited, Friden, is to be visited by the Midland section of the Institution of Gas Engineers on October 14, while the Institute of Metals is visiting the works on September 22.

THE ANNUAL CONVENTION of the Joint Iron Council will take place in London on November 1. It will be followed by the annual banquet on the same day. The principal guest will be the President of the Board of Trade, Mr. Peter Thorneycroft.

TUBE INVESTMENTS, LIMITED, announce the establishment of an applied research station at Walsall to supplement facilities already available at its research laboratories at Cambridge and Birmingham. The new station will be opened early in October.

LAST WEEK, the Rt. Hon. A. R. W. Low, C.B.E., Minister of State, Board of Trade, on behalf of the Ford Motor Car Company, Limited, presented Mr. Schreiner, of Vancouver, with the millionth car this company has exported since the war.

BRITISH INSTITUTE OF MANAGEMENT is holding its national conference in Harrogate from November 2 to 4. The theme of the conference is to be "Science and Management." Details of the conference are available from the Institute, 8, Hill Street, London, W.1.

THE IRON-ORE MINES of Kiruna, in northern Sweden, are to change completely from open-cast to underground workings by 1961. Annual production at the mines will be increased from 12,000,000 to 16,000,000 tons a year. Reserves are estimated to have a life of over another 100 years.

THE Industrial Association of Wales and Monmouthshire announces that in concurrence with the British Transport Commission and the British Liner Committee it has been decided to appoint a technical panel to examine the problems connected with dock charges at South Wales ports.

THE WEST BENGAL GOVERNMENT has entered into an agreement with a German concern for the construction of a proposed coke-oven plant at Durgapur, about 100 miles north-west of Calcutta. Construction work is expected to begin this year, with production starting three years hence.

YORKSHIRE COPPER WORKS, LIMITED, Leeds, were visited on September 7, by a party of careers masters from public and grammar schools attending a four-day convention on careers. The convention was arranged by the Leeds Chamber of Commerce on behalf of the Public Schools Appointments Bureau.

Mr. P. HOESLI, secretary of the Slough section of the London branch of the Institute of British Foundrymen, now informs us that Institute matters can be dealt with from his business address—c/o British Non-Ferrous Metals Research Association, 81, Euston Street, London, N.W.1. Telephone: Euston 6411.

EQUIPMENT manufactured by Hanovia Lamps, Slough, Bucks, will be shown at an exhibition to be held in the hall of the Midland Electricity Board at 247, Chester Street, Aston, Birmingham, 6, from October 3 to 14. The exhibits will show the wide range of applications for ultra-violet rays in industry, medicine and the home.

A NEW COURSE in factory management, prepared in conjunction with the Birmingham branch of the Institution of Works Managers, will be a feature of the 1955-56 session of the Birmingham College of Technology. It will be attended by 15 men between 25 and 35 who are already employed in some phase of works management.

Mr. A. B. WARING, chairman and managing director of Joseph Lucas (Industries), Limited, and chairman of the DSIR joint committee on Human Relations in Industry, is to speak on "Current Research into Human Relations in Industry," at the national conference of the Institute of Personnel Management at Harrogate from October 7 to 9.

THERE IS A RECORD NUMBER of employment vacancies in Chesterfield, according to the town Employment Committee's last report. Among industries most in need of men are foundries, engineering, building and civil engineering. The report states that 871 men could be absorbed immediately, and the town has vacancies for 157 women.

ASQUITH MACHINE TOOL CORPORATION, LIMITED, Halifax, has made an offer for the ordinary shares and participating preference shares of George Swift & Sons

News in Brief

(Holdings), Limited, also of Halifax. Shareholders of the latter firm had been advised in August that an offer might be made for all the issued ordinary shares. Full details of the present offer are to be posted to shareholders.

A NEW COMPANY has been formed by F. J. Collin, A.-G., suppliers of coke ovens and gasworks and by-product plant, of Dortmund, Germany, to represent its interests in Great Britain. The new company, F. J. Collin (U.K.), Limited, has its office at 9, Upper Belgrave Street, London, S.W.1 (telephone: SLOane 8172). The directors are Mr. R. Collin and Mr. E. Jaque and the manager is Mr. W. G. Carter.

LAYCOCK ENGINEERING COMPANY, LIMITED, Millhouses, Sheffield, have signed a manufacturing agreement with the German firm of Knorr-Bremse, of Munich, designers of braking systems for rail and road vehicles. The agreement primarily covers the manufacture in this country of the Knorr-Bremse designed air-braking equipment, but also provides for similar collaboration on other Knorr-Bremse designed components.

AT A RECENT MEETING of the Council of the Institution of Production Engineers, it was unanimously agreed that the opening paper of the Institution's annual aircraft production conference, organized by the southern section, should be given the status of a named paper to be known as the Lord Sempill Paper. This will commemorate both Lord Sempill's services to the Institution for many years and his life-long association with aeronautics.

THE GENERAL ELECTRIC COMPANY, LIMITED, has been entrusted by Australian Iron & Steel, Limited, with a contract, valued at £165,000 sterling, covering the complete electrical equipment for a two-stand temper mill for steel strip at Port Kembla, New South Wales. The mill will be similar in design to those now in commission at the Trostre works of the Steel Company of Wales, Limited, which were the first in the UK to operate at strip speeds of up to 4,000 ft. per minute.

THE FIRST of two industrial health surveys is to start within the next few weeks in Halifax. This is part of the plans of the Ministry of Labour for promoting the health and well-being of factory workers throughout the country and has been recommended by the Industrial Health Advisory Committee, the chairman of which is Sir Walter Monckton, Minister of Labour and National Service. The survey has the full backing of both sides of industry and medical organizations which are represented on the committee.

AT THE LAUNCHING of the 10,200-ton cargo ship Troutpool by Joseph L. Thompson & Sons, Limited, Sunderland, for Ropner & Company (Management), Limited, Darlington, Mr. David Ropner referred to the fact that the ship was being built on a fixed price basis. Urging the need for shipbuilders generally to quote fixed prices, he said that shipowners had to pay the wages of shipyard workers, yet had no say in fixing the wages. On the Continent it was possible to get fixed prices.

A PARTY of 31 senior boys from public schools and 39 undergraduates from British universities are each spending a week in Sheffield as guests of the United Steel Companies, Limited, in order to take part in short courses on iron and steel manufacture. The aim of both courses is to give an insight into the scientific basis and production methods of iron and steel making and shaping, some characteristic research problems and the way in which a steel company is managed. It is hoped that the courses will be a guide to those who attend in their choice of a future career.

EXTENSIONS to Glasgow's Royal Technical College are now being completed in an effort to satisfy the ever-increasing demands of industry for qualified engineers and other technicians. The work, begun in 1951, of enlarging the departments of civil, mechanical and mining engineering, and the later plans for further extensions, should be finished by the beginning of the 1956 session. Funds for financing the building programme have been provided partly by the College's own efforts, partly by the University Grants Committee, and partly by the Scottish Education Department.

BIRLEC, LIMITED, has concluded an arrangement with Otto Junker GMBH, of Lammersdorf, Germany, and the Ajax Engineering Corporation of Trenton, New Jersey, USA, for the development and marketing of the mains-frequency, coreless, induction melting furnace. This type of furnace, which is widely applicable to both ferrous and non-ferrous melting, including light metals and alloys, has been pioneered over a number of years in Germany by Junkers, who have made over 80 installations, totalling some 30,000 kw. More recently, in England, Birlec began development work in the same field and has a prototype unit in industrial use.

LADY FORBES, wife of the chairman of the Iron and Steel Board, will officially commission a new blast furnace at the Renishaw Iron Company, Limited, near Sheffield, on September 26. The new furnace will have an annual capacity of 75,000 tons. It has cost £150,000 and taken 18 months to construct. It is similar to the firm's present No. 2 furnace and replaces the old No. 1, which has been taken out of commission after 33 years' service. With additional mechanization it is expected that the new furnace will help to increase the firm's output of pig-iron by 50 per cent., and the two furnaces are estimated to produce jointly about 150,000 tons of pig-iron a year.

FIVE REPRESENTATIVES of the British steel industry are shortly to make a fact-finding tour of the Russian steel industry. The members will be:—Mr. Albert Jackson, general manager of the Appleby-Frodingham Steel Company, Limited, Scunthorpe; Mr. W. F. Cartwright, assistant managing director of the Steel Company of Wales; Sir Robert Shone, an executive member of the Iron and Steel Board; Mr. C. R. Wheeler, joint managing director of Guest, Keen & Baldwins Iron & Steel Company, Limited; and Mr. T. Dennison, technical adviser to the British Iron and Steel Federation. Soviet steel experts visited this country eight months ago. The date of the British visit has not yet been fixed.

WILLIAM DENNY & BROS., LIMITED, Dumbarton, have received an order from the Bowater Steamship Company, Limited, for a third newsprint-carrying ship. The new vessel will be similar in design and tonnage to the two previous ships ordered in 1951, being about 420 ft. in length and having a deadweight capacity of about 8,400 tons. Propelling machinery will consist of Parsons geared turbines driving a single screw and giving a service speed of about 14 knots. Delivery is to be in the summer of 1957. British Railways have placed an order with the Ailsa Shipbuilding Company, Troon, for a new dual-purpose passenger ship to cost about £400,000 for the Clyde services. This vessel will be the largest of its kind to go into service on the Firth and will be ready for operation early in 1957. The ship will have a capacity for about 1,000 passengers and at least 40 cars. There are already three dual-purpose car ferries operating on the Clyde.

Company News

WINGET, LIMITED, contractors' plant manufacturers, of Rochester (Kent)—A final dividend of 7 per cent. for the year ended March 31 last makes a 12 per cent. total for the third time in succession. Group profits contracted from £145,549 to £123,227.

JOWETT CARS, LIMITED—The directors announce that, as a result of recent negotiations, they understand that Blackburn & General Aircraft, Limited, will shortly make a formal offer to acquire the issued share capital at 3s. 3d. per share, involving £276,471.

RAILWAY & GENERAL ENGINEERING COMPANY, LIMITED—The company is paying a final dividend of 10 per cent., making 20 per cent. on the £75,000 ordinary capital for the year to March 31, an increase of 7½ per cent. over the previous year's single 12½ per cent. payment.

MUREX, LIMITED—The company is taking steps to withdraw from the copper-refining field because it is unremunerative, says Sir Arthur Smout, chairman, in his statement with the accounts. The management has now disposed, without loss, of certain long-term supply contracts with the object of closing the refinery within the next few months. It is unlikely that the company will re-enter this field, he adds.

PEASE & PARTNERS, LIMITED—At an extra-ordinary meeting the resolution to change the name to Pease Realization Company, Limited, was duly passed. Mr. Andrew Whyte, chairman, said with regard to the offer made by Hart Son & Company, Limited, for the share capital of the company that, up to September 3, acceptances had been received in respect of over 2,400,000 shares, representing approximately 70 per cent. of the issued capital.

B. ELLIOTT & COMPANY, LIMITED, machine tool manufacturers, of London, N.W.10—The company has a full order-book, reports Mr. J. Frye, the chairman, but export markets constantly become more and more difficult. Mr. Frye says he would welcome some form of incentive from the Government so as to encourage exporters to continue to expand their efforts in the overseas markets, where they face additional risk and expense by comparison with the home market.

INTERNATIONAL COMBUSTION (HOLDINGS), LIMITED—The company is paying an interim dividend of 7½ per cent. in respect of the year ending September 30 on the £2,877,735 ordinary capital as increased last May by a one-for-two scrip issue. This compares with 10 per cent. a year ago, equivalent to 6¾ per cent. on the present equity. The directors state, however, that the rate now declared is designed to bring the interim dividend more into line with the final distribution.

METAL INDUSTRIES, LIMITED—According to Mr. J. S. Hutchison, chairman, the company is overcoming the worst of the difficulties of unit management, of unwise contracts, and of initial heavy expenditures and innovations which had been lacking in immediate return. While these special costs were not at an end, they should show a diminution this year, but any improvement could be no more than modest and the balance could easily be upset by any serious variation in general trading conditions.

SHEEPBRIDGE ENGINEERING, LIMITED—During the year ended March 31 last, the company had to contend with rising wages and raw-material costs, resulting in a reduced group trading profit from £1,069,492 to £880,517. The position to-day, however, is stated by Mr. A. V. Nicolle, chairman, to be more promising than 12 months ago. There is an intensified demand for practically all products and the order-book is much heavier. New products, which were in the development stage a year ago, are now coming into production, such as long tubes of centrifugally cast-alloy steel.

WRIGHT, BINDLEY & GELL, LIMITED, wire and metal pressing manufacturers, etc., of Birmingham—The company has concluded a provisional agreement for the purchase of the capital of Gummers, Limited, brassfounders, of Rotherham, for £275,000. The bid is being financed as to about £100,000 from a surplus on the sale of assets and up to £185,000 by bank accommodation, subject to CIC consent. The board intends, in due course, to increase the paid-up capital, perhaps by a rights issue, to redeem the bank overdraft. In addition, negotiations have been entered into for acquiring a further business of a "somewhat smaller nature." This may involve a further £50,000.

Increases in Capital

LONDON ABRASIVES, LIMITED, increased by £180,000, in £1 ordinary shares, beyond the registered capital of £50,000.

RIDGEACRE FOUNDRY COMPANY, LIMITED, West Bromwich, increased by £18,000, in £1 shares, beyond the registered capital of £2,000.

BONNINGTON CASTINGS, LIMITED, Leith, Edinburgh, increased by £40,000, in £1 ordinary shares, beyond the registered capital of £60,000.

MANCUNA ENGINEERING, LIMITED, Denton (Lancs), increased by £35,000, in £1 ordinary shares, beyond the registered capital of £25,000.

JAMES COLLINS (BIRMINGHAM), LIMITED, brassfounders, etc., increased by £80,000, in £10 ordinary shares, beyond the registered capital of £70,000.

MARKHAM & COMPANY, LIMITED, ironfounders, etc., of Chesterfield, increased by £50,000, in £1 ordinary shares, beyond the registered capital of £350,000.

WILSON BROS. (LEEDS), LIMITED, makers of wood-working machinery, etc., increased by £20,000, in £1 ordinary shares, beyond the registered capital of £50,000.

JAMES FAIRLEY & SONS, LIMITED, ironmasters, steelmakers, etc., of Birmingham, increased by £27,362, in £1 "A" shares, beyond the registered capital of £10,000

LOBNITZ & COMPANY, LIMITED, dredger builders, engineers, etc., of Renfrew, increased by £200,000, in 10s. ordinary shares, beyond the registered capital of £300,000.

DAVISON & COMPANY (HEXHAM), LIMITED, iron, steel, and brass founders, etc., increased by £15,000, in £1 ordinary shares, beyond the registered capital of £5,000.

OUZLEDALE FOUNDRY COMPANY, LIMITED, Barnoldswick (Lancs), increased by £60,000, in £1 6 per cent. redeemable cumulative preference shares, beyond the registered capital of £10,000.

HENRY BALFOUR & COMPANY, LIMITED, gas and chemical engineers, ironfounders, etc., of Leven (Fife), increased by £125,000, in 5s. ordinary shares, beyond the registered capital of £150,000.

GEORGE RICHARDS & COMPANY, LIMITED, wood-working machinery manufacturers, etc., of Broadheath, Altrincham (Ches), increased by £750,000, in £1 ordinary shares, beyond the registered capital of £50,000.

C. S. MILNE & COMPANY, LIMITED, engineers, founders, smiths, etc., of London, S.E.8, increased by £40,000, in 15,000 ordinary and 25,000 8 per cent. cumulative preference shares of £1, beyond the registered capital of £10,000.

BIRFIELD INDUSTRIES, LIMITED, London, W.1, increased by £2,450,000, in 2,000,000 5 per cent. redeemable cumulative preference, 265,000 ordinary, and 185,000 unclassified shares of £1 each, beyond the registered capital of £1,300,000.

Contracts Open

The dates given are the latest on which tenders will be accepted. The addresses are those from which forms of tender may be obtained. Details of tenders with the reference ESB can be obtained from the Board of Trade Export Services Branch, Lacon House, Theobalds Road, London, W.C.1 (telephone: CHAncery 4411, ext. 738 or 771), unless otherwise stated.

MALAYA, September 20—Cast copper alloy pipe fittings, for the City Council of Singapore. (ESB/17965/55.)

FORMOSA—Textile machinery, for the Chu Tung Textile Company, Limited, Taiwan. (ESB/17803/55.)

PAKISTAN, September 29—Electric furnace, ovens, and accessories, for the Union Chimique Belge, Brussels, Belgium. (ESB/17101/55.)

Publications Received

BCIRA Journal of Research and Development. Vol. 6, No. 1. Published by the British Cast Iron Research Association, Alvechurch, Birmingham.

The contents of this issue are widely varied and range from heavy core-making to the properties of sands carrying coal-dust and wood-flour. Actually there are six reports. The first is "A Case Study in a Heavy Foundry," by Mr. J. Souter, who deals with the re-organization of the coreshop at the English Electric Company's Rugby works, which showed outstanding economies. The second report is from Mr. G. N. J. Gilbert, who shows how nodular irons when subjected to sub-critical annealing may result in brittle failure and how this can be averted by annealing above the critical temperature (900 deg. C.) Information is given in a report from Mr. F. C. Pearce, as to how fettling costs have been reduced, if not eliminated, due to the removal of the gates by the machine shop; instead of by grinding. The next report by Mr. H. Green is of interest for the laboratory as it discloses a method of determining the magnesium in nodular cast-iron. The last two papers are by Mr. R. G. Godding; the penultimate one deals with factors governing the expansion of both natural and synthetic moulding sands, whilst the last one tells of high-temperature properties of sands containing coal-dust and wood-flour.

Oils for Heat-treatment. Published by the Shell Petroleum Company Limited, Shell-Mex House, London, W.C.2.

When the older metallurgist read "quench in oil," he had but one medium in mind and that was whale oil. Modern research has changed all this, and now the great firm which has published this book not only offers mineral oils for quenching, but is in a position to enter into the whole technique of the subject of heat-treatment. Thus there is produced a veritable text-book on the subject running to over 100 pages and well illustrated by graphs and photographs. The book is virtually devoid of advertisement and is a genuine and successful attempt to give service to those whose job it is to control the properties of metals and alloys by heat-treatment. Seriously interested readers can no doubt receive a copy by writing to Shell-Mex House.

BISRA Survey, 1955. Issued by the British Iron and Steel Research Association, 11 Park Lane, London, W.1.

This is a very interesting survey, dealing with an industry somewhat akin to foundry practice. One article of interest to vitreous enamellers, is the disposal of waste acid. It seems that a new scheme has been devised for an extension of the system which involves the killing of the sulphuric acid to make iron-sulphate crystals. This latter material is broken up into iron oxide and usable sulphuric acid. It seems, however, that to work the processes economically the steelworks require still larger quantities of spent acid. Thus it would appear that there may be a new outlet for what is often a nuisance for vitreous enamellers to dispose of.

Zinc Dust in Protective Coatings. Issued by the Zinc Pigment Development Association, 34, Berkeley Square, London, W.1.

This well-illustrated 20-page booklet discusses the uses of zinc-rich paints. Whilst they cannot always replace galvanizing, they are competitive with other modern anti-corrosive paint coatings. The writer recommends its study by readers, to whom it is available on writing to the new office of the Z.D.A.

Book Review

Technologie von Graugusstücken (Technology of Grey-iron Castings), by Richard Meyer. Published by Wilhelm Knapp Verlag, 19 Mühlweg, Halle (Saale), Germany. Price 14.50 D.M.

The author, chief engineer of the former Krupp-Gruson works in Magdeburg, which specialize in very large grey-iron castings, publishes a collection of well-illustrated descriptions of making such castings, covering a life-time's experience in this special field.

As any achievements of a foundry are relative to the conditions and plant at its disposal, a detailed description is given of the foundry's melting units, comprising cupolas, Héroult electric-arc furnaces, rotary oil-fired reverberatory furnaces and oil-fired tilting crucible furnaces (for melting special cast iron with very high carbon contents requiring uniform composition).

The production of large castings is a complex matter dependent upon the combination of many factors. There are, of course, rules based on the collective experience of foundrymen over many years in such works, covering the technique used to run the castings, and this book is meant as a reference book for every foundryman who wishes to avail himself of frankly written reports which do not hide the difficulties encountered when the particular job was handled for the first time, or the toilsome ways to find the best method of production.

A chapter is devoted to the cement/sand moulding process for cast-iron propellers and ingot moulds up to 50 tons weight. The photographs, diagrams and photomicrographs in the book are of the highest standard, clear and easily understandable, so that students also can gain a valuable insight into the complexity of the problems involved. O.P.E.

House Organs

Staveley News—Summer, 1955. Issued by the Staveley Iron and Chemical Company, Limited, near Chesterfield.

This issue has now grown to a 64-page publication. Catering for works in one locality, the task of recording the various activities of the company is much more rewarding than when covering a number of branches spread all over the country. This task is being very well done and the magazine must be a real source of pleasure to the staff. The illustrated article on cacti, by Mr. R. J. Hooton of the Foundry Laboratory, is of interest to window-sill gardeners.

Wiggin Nickel Alloys. No. 33; issued by Henry Wiggins & Company, Limited, Wiggin Street, Birmingham, 16.

This issue contains three articles of interest. They are "Nimonic 90 Springs Meet a Shell-Moulding Problem," "A Matter of Gravity" (Gravity die-castings), and "Longer Life for Conveyor Belts."

Storage Equipment. In a folder, which fortunately never reveals itself upside down, the Welconstruct Company, Limited, Greville Buildings, Cherry Street, Birmingham 2, caption, illustrate and price a wide range of office and workshop storage equipment—extended to include partitioning and trucks. The equipment shown covers shelves, racks, bins and cupboards. It is available to readers on writing to Cherry Street.

Personal

Mr. VERNON YOUNG has been appointed chairman of International Combustion Limited, London, W.C.1.

Mr. JOSEPH PICKIN has resigned from the board of Alfred Herbert, Limited, machine-tool manufacturers, Coventry.

Mr. A. E. CABELDU has resigned from the board of Catalin, Limited, industrial synthetic resin manufacturers, Waltham Abbey, Essex.

Mr. E. M. BENJAMIN has relinquished the post of managing director of British Oilfield Equipment Company, Limited, Leeds, and has resigned from the board.

Mr. DOUGLAS J. AULT, director and secretary of Tangyes, Limited, Smethwick, Staffs, has been appointed assistant managing director (administrative) of the company.

Mr. R. S. COCHRANE, for several years manager of Nettleton ironstone mine, owned by John Lysaght's Scunthorpe Works, Limited, has left the district to take another post.

Mr. R. DUTTON-FORSHAW, a director of the Burton-wood Engineering Company, Limited, has been appointed to the board of Sheepbridge Engineering, Limited, Chesterfield.

Mr. E. O. CHAPMAN has been appointed sales manager of Gent & Company, Limited, electrical and horological engineers, of Leicester. He has been sales manager of the clock division since 1949.

Mr. EDWARD R. HILTON has been appointed an assistant to the sales manager of the British materials handling division of the Yale & Towne Manufacturing Company, Wednesfield, Wolverhampton.

THE MINISTER OF FUEL AND POWER has appointed Mr. R. J. BUCKINGHAM, of Hammersmith, and Mr. J. DAVIES, of Orpington (Kent), to be members of the Domestic Coal Consumers' Council.

Mr. J. W. LENNOX, a director and general manager of Sintered Products, Limited, has, in addition, been appointed general manager of Sheepbridge Alloy Castings, Limited, Sutton-in-Ashfield (Notts).

Mr. JAMES ALDERSON, who has been secretary for 33 years, and a director for 11 years, of Hartley & Sugden, Limited, boilermakers, of Halifax, has received a presentation from the directors and staff on his retirement.

Dr. A. H. M. ARNOLD, head of the electronics section of the electricity division of the National Physical Laboratory, has been appointed to the Readership in Electrical Engineering of London University, tenable at King's College.

Mr. F. H. SCHROEDER, a director of Lancashire Dynamo Holdings, Limited, is leaving this month on a visit covering all the countries in Central and South America and the Caribbean on behalf of the group. He is expected to return in February.

Mr. FRANK SOMERS, O.B.E., director of the Halesowen engineering firm of Walter Somers, Limited, and his wife, Mrs. K. Somers, celebrated their golden wedding on August 23. Mr. and Mrs. Somers, who at one time lived at Otterbourne Court, Halesowen, now reside at Barmouth.

Mr. G. M. THOMPSON, chairman of Samuel Thompson & Company (Millfields), Limited, ironfounders, of Wolverhampton, was among 41 members of the company who received presentations for more than 25 years' service at a jubilee dinner to celebrate the firm's incorporation in 1905. Mr. Thompson has been 55 years with the company.

BIRLEC, LIMITED, Birmingham, announce the appointment of Mr. ROY BURGES as publicity manager, in succession to Mr. J. C. MANTELL, M.B.E., with effect from September 19. Mr. Burges, who read physics at St. Peter's Hall, Oxford, joins his new company from Langley Alloys, Limited, Slough. Mr. Mantell remains within the A.E.I. group of companies, in which he will take a two years' training course at the British Thomson-Houston Company, Limited, Rugby.

THE METAL INDUSTRIES, LIMITED, group announces the appointment of Mr. H. MURRAY TAYLOR and Mr. J. LIGHTBODY as directors of Metal Industries (Salvage), Limited. Mr. J. BRUCE, a director of the Hughes Bolckow Shipbreaking Company, Limited, has joined the board of Shipbreaking Industries, Limited. Mr. G. P. BELSHAM has been appointed sole managing director of Brookhirst Switchgear, Limited, Chester, while Mr. D. W. KENT has been appointed sole managing director of the Igranic Electric Company, Limited, Bedford. On taking up this appointment he will relinquish his seat on the board of Sentinel (Shrewsbury), Limited, which was recently joined by Mr. E. BRUCE BALL, who has now also joined the boards of Fawcett, Preston & Company, Limited, Finney Presses, Limited, and Ferrous Castings, Limited.

Obituary

MR. JOHN WILLIAM GREENWOOD, formerly traffic manager at Thos. Firth & John Brown, Limited, steel manufacturers, Atlas Works, Sheffield, has died at the age of 72.

The death has occurred of Mr. ARCHIBALD C. J. WALL, a director of Charles Roberts & Company, Limited, railway stock and equipment manufacturers, etc., of Horbury Junction, near Wakefield. He also served as chairman of the Midland Mining & Trading Company, Limited.

THE FUNERAL took place on September 5, of Mr. GEORGE FREDERICK FRANKCOM, of Guiseley, near Leeds, founder and managing director of George Frankcom, Limited, brassfounders, Hallam Mills, Guiseley. Mr. Frankcom, who was 68, served with the Duke of Wellington's Regiment in the first world war and in the last war, as a member of the Observer Corps.

Mr. JOHN SPENCER, who has died at the age of 83, was senior joint managing director of William Towler & Company, Limited, ironfounders, etc., of Leeds. He joined the company 64 years ago and became successively cashier and works manager before his appointment as joint managing director in 1926. He had served as chairman of the Leeds and District Ironfounders' Association.

THE DEATH took place suddenly on September 11 of Mr. HOWARD EVANS, A.Met., F.I.M., superintendent of the Mond Nickel Company, Limited, research laboratory at Birmingham. Mr. Evans was born in 1907 and studied metallurgy at Sheffield University, where he graduated A.Met., with the award of the Mappin Medal and Premium in 1930. He was first employed in the research department of the Metropolitan-Vickers Electrical Company, Limited, before joining the Mond Nickel Company, Limited, in 1938, as research metallurgist in their Birmingham laboratory. He was associated with a wide variety of research projects in both the ferrous and non-ferrous fields, and in 1947, jointly with colleagues, he presented a paper before the Institute of British Foundrymen on precision investment casting.

New Patents

(Copies of complete specifications are obtainable from the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, London, W.C.2, price 3/-.)

735,718. Luke & Spencer, Limited, Broadheath, Altrincham.

An improvement in grinding machines, which have a frame on which a grinding wheel is mounted for rotation about a horizontal axis. A work rest is provided on which components to be treated can be supported while being presented to the rotating wheel. The entry of air to the space beneath this work rest where the grinding wheel enters the guard is controlled. This air control considerably reduces the quantity of dust and particles thrown off by the uncovered part of the wheel.

735,770. Polygram Casting Company, Limited, Power Road, Gunnersbury, London, W.4.

A method for making shell moulds. A frame is attached around and at or near the edges of the working face of the patternplate so that it will stand up from the working face. After the frame has been disconnected from the patternplate, the frame and the half mould are stripped from the patternplate and pattern by applying force to the projecting parts or lugs of the frame while the patternplate is held in a fixed position.

735,809. Compagnie Francaise des Metaux, 7 Rue du Cerque, Paris, France.

A process for the continuous or semi-continuous casting of metals or alloys, where a projection of atomized cooled liquid is utilized for the solidification of metal leaving the mould. The drops of atomized liquid are sufficiently small to enable vaporization to take place at the exact point of contact with the metal.

735,858. Ford Motor Company, Limited, 88, Regent Street, London, W.1.

Improvements in nodular-iron castings. In the production of nodular cast iron, magnesium-bearing molten metal is treated during the casting process with a flux which wets the magnesium oxide. The flux can be borax, boric acid, fused borax, alkali metal fluoraborates or mixtures containing a double chloride of an alkali metal and magnesium. The flux can be added alternatively to the ladle and can also be contained in the casting moulds.

735,965. Tage Debusmann Madsen, 20 Stampgaten, Goteburg, Sweden.

A cast-iron alloy for cylinder liners of piston engines, especially of internal combustion engines. The cast iron is alloyed with vanadium, titanium, and copper in the following ratios:—V=0.15 to 0.5 per cent. of alloy; Ti=$\frac{1}{8}$ to $\frac{1}{4}$ of the amount of V; Cu=two to six times the amount of V; and C=2.50 to 3.60 per cent. of the alloy.

736,019. Richards (Leicester), Limited, Phoenix Iron Works, Leicester.

This patent is for an improved moulding box, each half of which is made up of four separately constituted wall forming plates, that is a pair of side plates and a pair of end plates. The plates of each pair have symmetrical and like lateral edges so as to be interchangeable. The lateral edges of the end plates are abutted flat against and between the opposed lateral and parts of the side plates.

Wages and Dividends

In an open letter to the Press, aimed at removing continued misconceptions over the relation between dividends, wages, and salaries, Sir John Braithwaite, chairman of the Stock Exchange, says that any broad consideration of these matters must go back to the spring of 1948, when Sir Stafford Cripps, with the support of the TUC, called for restraint all round.

"The Federation of British Industries obtained from its members an agreement not to increase dividends for 1948, and again for 1949, and Sir Stafford Cripps acknowledged in the House of Commons that these agreements had been substantially observed. (There was in fact some increase in the total of interest and dividends, chiefly due to the inclusion of new loan capital.)

"The fact that wages and salaries rose by £1,040,000,000, or 19 per cent., during the two years when dividend limitation was substantially observed must be borne in mind in considering the rises in dividends that came later; but here again no criticism is implied of this rise in wages and salaries. Neither of the post-war Governments has been able to prevent a steady rise in the cost of living, though happily this rise has throughout kept well behind the compensating rise in wages and salaries.

"The published material on these subjects shows the following:—

"The total of wages and salaries for the year ending December 31, 1954, was £9,265,000,000, as against a total of £1,122,000,000 for interest and dividends on securities quoted on the Stock Exchange; or over eight times as great.

"Wages and salaries have advanced since 1947 by 69.2 per cent (£3,790,000,000) against an increase of 32.1 per cent. (£273,000,000) in interest and dividends (of which ordinary dividends constitute 39.6 per cent.): that is to say, that the rise in wages and salaries is more than double the rise in interest and dividends by percentage, and nearly 14 times as much by volume.

"In each year since 1947, the rise in wages and salaries has exceeded by at least £80,000,000 the whole sum of the rise in interest and dividends on Stock Exchange securities over the entire seven-year period, 1948-1954.

"Company trading profits have risen since 1947 by 51.6 per cent. (£877,000,000) against the rise in wages and salaries of 69.2 per cent (£3,790,000,000): that is to say, that the rise in wages and salaries has been appreciably more than the rise in company trading profits by percentage, and four times more by volume."

Recent Wills

Downs, William, formerly a director of Bairds & Scottish Steel, Limited £17,241

Towler, J. M., joint managing director of Towler Bros. (Patents), Limited, hydraulic pump manufacturers, of Rodley, Leeds £17,059

Agnew, Sir Arthur, late a director of Richard Thomas & Baldwins, Limited, the Elba Tinplate Company, Limited, Swansea, and other companies £241,098

Kershaw, Cecil, late managing director of A. Kershaw & Sons, Limited, precision instrument makers, of Leeds, and of British Optical & Precision Engineers, Limited £108,721

Pickering, W. B., a former director and commercial manager of Hadfields, Limited, steelmakers, of Sheffield, a former president of Sheffield Chamber of Commerce and an executive member of the Association of British Chambers of Commerce... £104,264

Craggs, H. F., chairman and managing director of the Goole Shipbuilding & Repairing Company, Limited, which he founded 55 years ago, and chairman of Clelands (Successors), Limited, Wallsend, and Brown's Shipbuilding & Dry Dock Company, Limited, Hull £173,332

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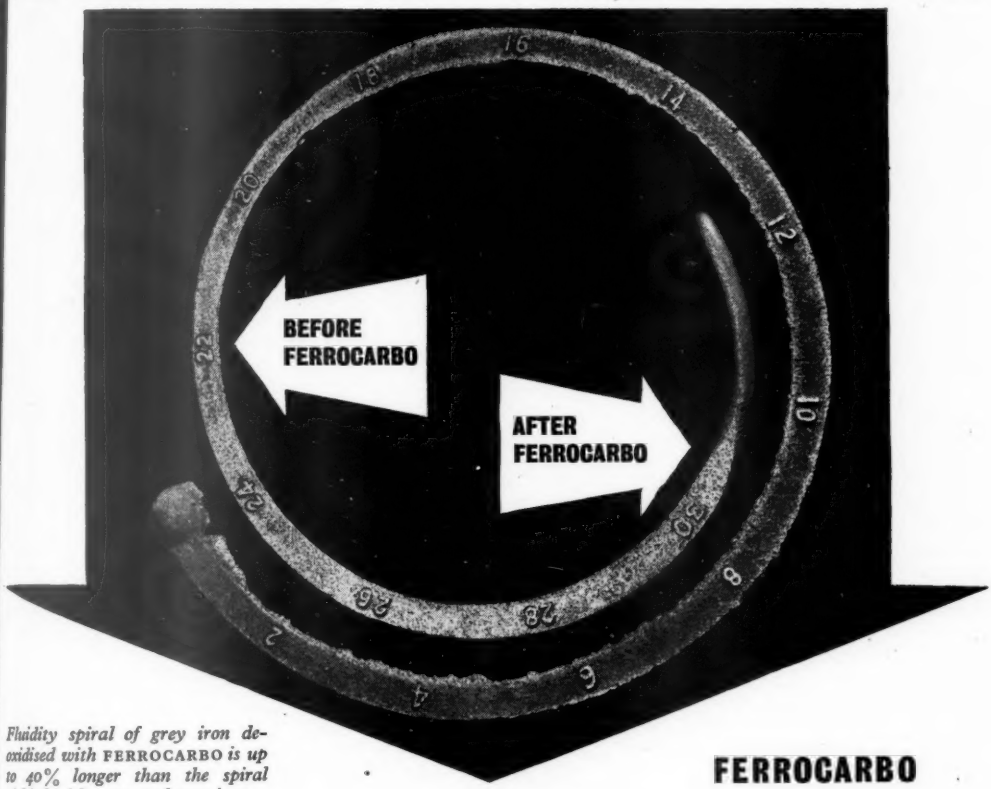

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Raw Material Markets

Iron and Steel

Expansion of pig-iron production is still painfully slow. The bulk of the blast-furnace capacity is engaged in servicing the steel plants, and only minimum tonnages of pig-iron are available for other consumers. Somehow or other the foundries are managing to maintain their output of castings at a high level, but the better grades of pig-iron, such as hematite and low-phosphorus iron, are very scarce and cupola mixtures have to made up with such grades as are immediately available. Some iron is still being exported, but in this respect it is a two-way traffic, as even larger tonnages are being imported, chiefly for use in the steelworks.

Since the holidays, the supply and demand position in semi-finished steel seems to have been restored to an approximate equilibrium. Deliveries of home-produced material have been on a better scale, and although imports are still necessary, re-rollers no longer complain of crippling scarcities. Most of the mills are now restored to full-scale activity and with an abundance of orders in hand, the outlook for this branch of the steel industry is much better. Many of the mills, however, are handicapped by a shortage of skilled labour.

Far from there being any abatement of the pressure for supplies of finished steel products, demand seems to be leaping still further ahead of manufacturing capacity. The steel boom, in fact, has become world-wide in its incidence. Moreover, in the light of subsequent events the last rise in British steel prices, which at the time occasioned some criticism, is now seen to have been modest. Delivery dates constitute the one insuperable barrier to brisk business. Overloaded as they are with orders which will absorb maximum outputs for months ahead, rollers of flat steel products, heavy constructional material, rails, and wire can only quote for next year's delivery.

Non-ferrous Metals

The Rhodesian Selection Trust group and the Northern Rhodesia European Mineworkers' Union reached an agreement on African advancement on the Rhodesian Copperbelt at the weekend. The union has dropped its demand for the right to veto further African advancement and has declared " that it has no intention of unreasonably withholding its consent in the future to any scheme of African advancement which does not conflict with the union's desire to ensure reasonable prospects for the European employees of the companies." The agreement is broadly similar to that signed by the Anglo-American group at the end of July. It will run for three years and provides that jobs undertaken by Europeans will be examined by an independent firm of industrial consultants during that time.

The prospect of peace on the Copperbelt may have had something to do with the relatively large drop in the price of copper in London early this week. A more likely explanation, however, would appear to be that there are rising hopes that the US will release Chilean copper from the stockpile.

Prices rallied in London on Tuesday afternoon on the announcement that the American Smelting & Refining Company has raised its price for electrolytic copper to domestic consumers to 50 cents a pound, a difference of 7 cents from the regular producer quotation of 43 cents.

The dock strike in the US has also been responsible for a small rise in the spot price for tin over there. The market here has been quiet, but fairly firm, with supplies adequate to meet all demands. Renewed uneasiness may develop over the dispute between the Eastern Smelting Workers' Union and the Penang Smelter. The two parties have agreed to a final meeting which is taking place to-day (Thursday).

The lead price has been firm on both sides of the Atlantic, although the turnover in both markets has been less than in recent weeks.

Demand for zinc here and in the US has also eased somewhat from its previous high levels, but the undertone is steady. Zinc stocks held by US smelters at the end of August were at their lowest level for several years and amounted to 46,087 short tons, compared with a revised figure of 51,920 tons in July and 193,253 tons a year ago.

Official metal prices were as follow:—

COPPER, Standard—*Cash*: September 8, £393 10s. to £394; September 9, £396 10s. to £397; September 12, £385 to £386; September 13, £378 10s. to £379; September 14, £388 to £389.

Three Months: September 8, £388 to £388 10s.; September 9, £391 to £392; September 12, £380 to £381; September 13, £373 to £374; September 14, £383 10s. to £384.

TIN, Standard—*Cash*: September 8, £744 to £744 10s.; September 9, £744 10s. to £745; September 12, £744 10s. to £745; September 13, £744 10s. to £745 10s.; September 14, £745 10s. to £746.

Three Months: September 8, £744 10s. to £745; September 9, £744 10s. to £745; September 12, £745 to £745 10s.; September 13, £744 10s. to £745; September 14, £746 to £746 10s.

LEAD—*First half September*: September 8, £107 to £107 10s.; September 9, £108 to £108 5s.; September 12, £107 10s. to £108; September 13, £107 10s. to £107 15s.; September 14, £107 15s. to £108.

First half December: September 8, £107 to £107 5s.; September 9, £107 15s. to £108; September 12, £107 10s. to £107 15s.; September 13, £107 5s. to £107 10s.; September 14, £107 10s. to £107 15s.

ZINC—*First half September*: September 8, £92 5s. to £92 10s.; September 9, £92 15s. to £93; September 12, £92 12s. 6d. to £92 17s. 6d.; September 13, £92 5s. to £92 10s.; September 14, £92 to £92 5s.

First half December: September 8, £91 10s. to £91 15s.; September 9, £92 to £92 15s.; September 12, £91 15s. to £92; September 13, £91 15s. to £92; September 14, £91 15s. to £92.

A NEW COURSE in factory management, prepared in conjunction with the Birmingham branch of the Institution of Works Managers, will be a feature of the 1955-56 session of the Birmingham College of Technology. It will be attended by 15 men between 25 and 35 who are already employed in some phase of works management.

AT the Engineering, Marine and Welding Exhibition, and Foundry Trades Exhibition at Olympia, which closes to-day, the exhibits of Murex Welding Processes, Limited (stand 2, row W, Empire Hall), are of special interest as they not only include new electric-arc welding equipments and electrodes, but they demonstrate how the firm's research department aids industry. Marine equipment at the Exhibition includes a model of a 5,500-h.p. gas turbine, developed by the British Thomson-Houston Company, Limited (National Hall, ground floor, row N, stand 6), and a working model of a 2,200-h.p. triple-expansion steam engine with propeller, rudder and after-end of a ship (North Eastern Marine Engineering Company, Limited, and George Clark (Sunderland), Limited, Grand Hall, ground floor, row G, stand H).

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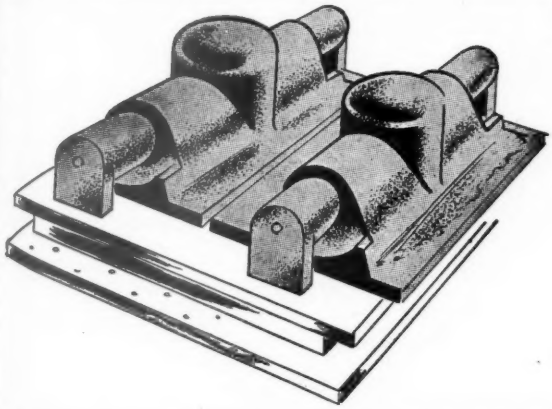

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PIG-IRON

Foundry Iron.—No. 3 IRON, CLASS 2:—Middlesbrough, £17 1s. 0d.; Birmingham, £16 13s. 3d.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent. P, £18 12s. 9d., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si), d/d within 60 miles of Stafford, £19 8s. 3d.

Scotch Iron.—No. 3 foundry, £19 5s. 6d., d/d Grangemouth.

Cylinder and Refined Irons.—North Zone, £21 3s. 0d.; South Zone, £21 5s. 0d.

Refined Malleable.—P, 0.10 per cent. max.—North Zone, £22 0s. 0d.; South Zone, £22 3s. 0d.

Hematite.—Si up to 2 per cent., S. & P. over 0.03 to 0.05 per cent. :—N.-E. of England (local iron), £19 5s.; Scotland (Scotch iron), £19 11s. 6d.; Sheffield, £20 12s. 0d.; Birmingham, £20 19s. 6d.; Wales (Welsh iron), £19 11s. 6d.

Basic Pig-iron.—£16 16s. 6d. all districts.

FERRO-ALLOYS

(Per ton unless otherwise stated, delivered)

Ferro-silicon (6-ton lots and over).—45 per cent. Si, £40 15s. 0d., scale 15s. per unit; 75 per cent. Si, £63 0s. 0d., scale 16s. per unit.

Ferro-vanadium.—50/60 per cent., 23s. 8d. to 25s. 0d. per lb. of V.

Ferro-molybdenum.—65/75 per cent., carbon-free, 11s. 0d. per lb. of Mo.

Ferro-titanium.—20/25 per cent., carbon-free, £230 0s. 0d.; 38/40 per cent., £279 0s. 0d.

Ferro-tungsten.—80/85 per cent., 18s. 2d. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 21s. 2d. per lb. of W.

Ferro-chrome (6-10 ton lots).—4/6 per cent. C, £83 0s. 0d. to £86 0s. 0d., basis 60 per cent. Cr, scale 25s. 0d. per unit; over 6 per cent. C, £81 0s. 0d. to £84 0s. 0d., basis 60 per cent. Cr, scale 24s. 0d. per unit; 2 per cent. C* 1s. 11½d. per lb. Cr.; 1 per cent. C,* 2s. 0d. per lb. Cr; 0.15 per cent. C,* 1s. 11d. to 2s. 1d. per lb. Cr; 0.10 per cent. C,* 1s. 11d. to 2s. 2d. per lb. Cr; 0.06 per cent. C,* 2s. 3d. per lb. Cr.

Metallic Chromium.—98/99 per cent., 7s. 0d. to 7s. 6d. per lb.

Metallic Manganese.—93/95 per cent., carbon-free, £249 0s. 0d.; 96/98 per cent., £269 0s. 9d.

Ferro-columbium.—60/75 per cent., Nb + Ta, 37s. per lb., Nb. + Ta.

Ferro-manganese (home).—78 per cent., £54 10s. 0d.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—BASIC: Soft, u.t., £26 19s. 0d.; tested, 0.08 to 0.25 per cent. C, £27 19s. 0d.; hard (0.41 to 0.60 per cent. C), £29 5s. 6d.; silico-manganese, £36 7s. 6d.; free-cutting, £31 0s. 6d. SIEMENS MARTIN ACID: Up to 0.25 per cent. C, £34 12s. 0d.; silico-manganese, £36 7s. 6d.

* Average 68-70 per cent.

Billets, Blooms, and Slabs for Forging and Stamping.—Basic, soft, up to 0.25 per cent. C, £31 11s. 0d.; basic, hard, over 0.41 up to 0.60 per cent., C, £32 13s. 6d.; acid, up to 0.25 per cent. C, £35 12s. 6d.

FINISHED STEEL

Heavy Plates and Sections.—Ship plates (N.-E. Coast), £33 1s. 6d.; boiler plates (N.-E. Coast), £35 11s. 6d.; floor plates (N.-E. Coast), £34 10s. 6d.; sectional material, N.-E. Coast, £30 19s. 6d.

Small Bars, Sheets, etc.—Rounds and squares, under 3 in., untested, £33 19s. 6d.; flats, 5 in. wide and under, £33 19s. 6d.; hoop and strip, £35 1s. 6d.; uncoated strip mill coils, hot rolled, under 3mm. to 12g., £36 5s. 0d.; black sheets (hand mill), 17/20 g., £46 13s. 6d.; galvanized corrugated sheets, 24 g., £58 11s. 0d.

Alloy Steel Bars.—1 in. dia. and up: Nickel, £58 0s. 3d.; nickel-chrome, £81 10s. 0d.; nickel-chrome-molybdenum, £92 7s. 6d.

NON-FERROUS METALS

Copper.—Cash, £388 0s. 0d. to £389 10s. 0d.; three months, £383 10s. 0d. to £384 0s. 0d.; settlement, £389 0s. 0d.

Copper Tubes, etc.—Solid-drawn tubes, 3s. 8½d. per lb.; rods, 430s. 6d. per cwt. basis; 20 s.w.g., 463s. 9d. per cwt.

Tin.—Cash, £745 10s. 0d. to £746 0s. 0d.; three months, £746 0s. 0d. to £746 10s. 0d.; settlement, £746 0s. 0d.

Lead (Refined Pig).—First half September, £107 15s. 0d. to £108 0s. 0d.; first half December, £107 10s. 0d. to £107 15s. 0d.

Zinc.—First half September, £92 0s. 0d. to £92 5s. 0d.; first half December, £91 15s. 0d. to £92 0s. 0d.

Zinc Sheets, etc.—Sheets, 15 g. and thicker, all English destinations, £124 2s. 6d.; rolled zinc (boiler plates), all English destinations, £121 17s. 6d.; zinc oxide (Red Seal), d/d buyers' premises, £103 0s. 0d.

Brass Tubes, etc.—Solid-drawn tubes, 2s. 10⅞ d. per lb.; rods, drawn, 3s. 8¾d.; sheets to 10 w.g., 365s. 9d. per cwt.; wire, 3s. 6d.; rolled metal, 351s. 6d. per cwt.

Brass (Brazing).—BS1400, B3 (65/35), £237; B6 (85/15), —; BS249, —.

Brass (High Tensile).—BS1400, HTB1 (30 tons), £290; HTB2 (38 tons), 298 HTB3 (48 tons), —.

Gunmetal.—RCH, 3/4 per cent. tin, —; BS1400, LG2 (85/5/5/5), £331; LG3 (86/7/5/2), £342; G1 (88/10/2/½), £407; (88/10/2/1), £398.

Phosphor Bronze.—BS1400, PB1 (AID released), £423 per ton.

Phosphor Bronze Strip, etc.—Strip, 513s. 3d. per cwt.; sheets to 10 w.g., 536s. 9d. per cwt.; wire, 5s. 2½d. per lb.; rods, 4s. 6½d.; tubes, 4s. 5d.; chill cast bars: solids 4s. 6½d., cored 4s. 7½d. (CHARLES CLIFFORD, LIMITED).

Nickel Silver, etc.—Rolled metal, 3 in. to 9 in. wide × 0.056, 4s. 5d. per lb.; round wire, 10g. in coils (10 per cent.), 4s. 9½d.; special quality turning rod, 10 per cent., ½ in. dia., in straight lengths, 4s. 8½d. All prices are net.

Other Metals.—Magnesium, ingots, 2s. 4d. per lb. Antimony, English, 99 per cent., £210 0s. 0d. Quicksilver, ex-warehouse, £92 0s. 0d. to £95 0s. 0d. Nickel, £519 0s. 0d. Aluminium, ingots, £171 0s. 0d.; aluminium bronze (BS1400), AB1, £372; AB2, —. Solder, brazing, BS1845, 3s. 0½d. lb.; granulated, 3s. 4½d. lb.

Forthcoming Events

SEPTEMBER 15

Incorporated Plant Engineers

Blackburn branch:—"Corrosion—Prevention and Control," by Dr. G. Butler, 7.30 p.m., at the Golden Lion Hotel.

SEPTEMBER 16

Institute of Industrial Supervisors

Mid-Somerset section:—"The Foreman's Future," by S. Waugh, 7.30 p.m., at Clark, Son & Morlands, Glastonbury.

SEPTEMBER 19-23

Institute of Metals

Annual meeting in Buxton. (Details available from the secretary, 4, Grosvenor Gardens, London, S.W.1.)

SEPTEMBER 21

Incorporated Plant Engineers

Kent branch:—"Building Construction for Industry," 7 p.m., at the Bull Hotel, Rochester.

Institute of Industrial Supervisors

Redditch section:—"Factory Acts and the Foreman," by R. Bramley Harker, 7.30 p.m., at the College of Further Education, Easemore Road.

SEPTEMBER 22

Institute of British Foundrymen

Southampton section:—"Some Foundry Problems," by G. J. Rogers, 7.30 p.m., at the Technical College, St. Mary's Street.

Association of Bronze and Brass Founders

Midland area:—Members meeting at 11.45 a.m. at the Victoria Hotel, Wolverhampton, followed after lunch by Advisory Service meeting, open to all founders, at 2.15 p.m., with "CO_2 Process," lecture and film by A. Talbot.

SEPTEMBER 24-25

Institute of British Foundrymen

Annual meeting and competition of the Golfing Society at Woodhall Spa, Lincolnshire (details from the secretary of the Society, P. G. Pennington, c/o G. Oxley & Sons, Limited, Vulcan Foundry, Sheffield).

Changes of Name

Among companies which have recently changed their names are those listed below. The new titles are given in parentheses.

CAMBOURNE PLANT HIRE COMPANY, LIMITED, 189, Regent Street, London, W.1 (Millnex, Limited).

PROWTING (PLANT), LIMITED, 127, High Street, Ruislip, Middx. (Prowting Plant Hire, Limited).

CONVILLE ENGINEERING COMPANY, LIMITED, 3, Abchurch Yard, London, E.C.4 (Conville, Limited).

RILEY STOKER COMPANY, LIMITED, 12, Woburn Place, London, W.C.1 (Riley (IC) Products, Limited).

MANCHESTER REPETITION ENGINEERS, LIMITED, 150, Chell Street, Manchester, 12 (Skil Engineers, Limited).

FAYS INDUSTRIES (LONDON), LIMITED, 81, Barrowgate Road, W.4 (Fays (Non-Ferrous) Metals, Limited).

FACTORY SUPPLIES (LONDON), LIMITED, 37, Sheen Road, Richmond, Surrey (Durable Abrasives, Limited).

DURABLE ABRASIVES, LIMITED, 37, Sheen Road, Richmond, Surrey (General Factory supplies, Limited).

DEESIDE SALVAGE COMPANY, LIMITED, 30/31, Old Bank Buildings, Chester (Deeside Metal Company, Limited).

HEATHFIELD CABLE & ENGINEERING WORKS, LIMITED, Heathfield, Fareham, Hants (Heathfield Builders, Limited).

CYE-ARC, LIMITED, mechanical and electrical engineers, etc., of 27/29, New North Road, London, N.1 (E.E.S., Limited).

ADVANCE ENGINEERING PRODUCTS, LIMITED, 287a, High Road, Wood Green, London, N.22 (Storax, Limited).

SHIELD ALLOYS, LIMITED, 19, Royal Mint Street, London, E.1 (Shield Trust, Limited).

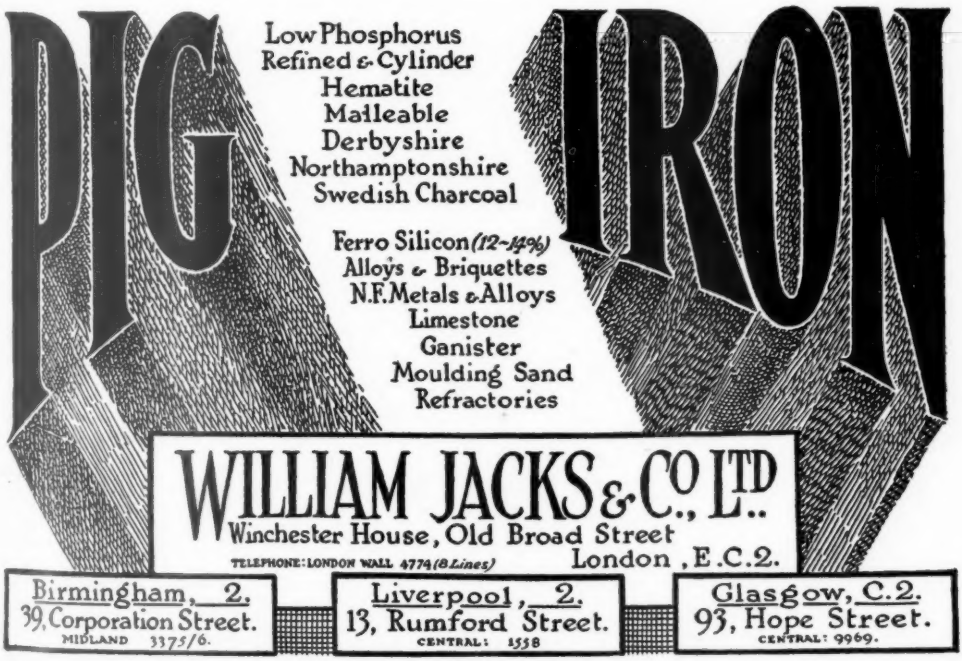
JEKA PRECISION ENGINEERS, LIMITED, Harlequin Avenue, Great West Road, Brentford, Middx (W. J. H. Lambert, Limited).

VICTORIA BODIES, LIMITED, Shell Buildings, Blackheath, Birmingham (Victoria Engineering & Manufacturing (Blackheath), Limited).

FOX & SMITH, LIMITED, manufacturers of and dealers in industrial machinery, etc., of 26, East Tower Street, Carlisle (Esklea Nominees, Limited).

PROGRESS ENGINEERING COMPANY (SOUTHEND), LIMITED, 133A, East Street, Prittlewell, Southend-on-Sea (E.T.R. Grandison, Limited).

E. L. PITT & COMPANY (BIRMINGHAM), LIMITED, manufacturers of and dealers in non-ferrous residues, etc., of Coronation Works, Wellington Street, Perry Barr, Birmingham (Pittrail, Limited).



CLASSIFIED ADVERTISEMENTS

PREPAID RATES: Twenty words for 5s. (minimum charge) and 2d. per word thereafter. Box Number 2s. extra (including postage of replies).

Advertisements (accompanied by a remittance) and replies to Box Numbers should be addressed to the Advertisement Manager, Foundry Trade Journal, John Adam House, 17/19, John Adam Street, Adelphi, London, W.C.2. if received by first post Tuesday advertisements can normally be accommodated in the following Thursday's issue.

SITUATIONS WANTED

FOUNDRY DIRECTOR, dissolution. Free in November, desires position as representative, or similar. Willing to move. Age 40. Own car available. Box FD483, FOUNDRY TRADE JOURNAL.

JOBBING IRON MOULDER (aged 31 years), experienced in all classes of moulding, dry and green sand, and cement work, segment and strickles, seeks position as Foreman.—BOX JI503, FOUNDRY TRADE JOURNAL.

FOUNDRY WORKS MANAGER (42) M.I.B.F. seeks change, 16 years Managerial experience in Machine Tools. Textile and Light Castings for the Domestic Trades; Machine Shop and Light Assembly; Vitreous Enamelling of cast iron. Excellent Industrial record, Representation considered. Box FW499, FOUNDRY TRADE JOURNAL.

PATTERNMAKER requires employment in Warwick-Leamington-Spa Area. Experienced in first-class wood patterns. City and Guilds. Pattern-making and foundry technology.—Box PR505, FOUNDRY TRADE JOURNAL.

CHEMIST (37), desires change. Experienced ferrous and non-ferrous fuels, oils, waters, sands and physical testing, Foundry and melting practice. Can assume complete control. Salary £600—£650. Glasgow area preferred. Box CD509, FOUNDRY TRADE JOURNAL.

FOUNDRY WORKS MANAGER, age 45 (practical man) 18 years managerial experience, seeks position. Sound experience in modern methods of production, grey, non-ferrous, including shell moulding. Box FW510, FOUNDRY TRADE JOURNAL.

SITUATIONS VACANT

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 *inclusive or a woman aged* 18-59 *inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order,* 1952.

REQUIRED.—ASSISTANT to Plant Engineer. Experience in foundry maintenance an advantage. Apply with full details of age, experience, qualifications and salary required, to BRITANNIA IRON & STEEL WORKS LTD., Bedford.

DRAUGHTSMEN required, preferably with Gravity Die experience. First class jig and tool draughtsmen wishing to broaden experience might suit. Pension Scheme in operation. Apply JOHN DALE LTD., London Colney, Herts.

RADIOGRAPHER required as Assistant in Shipbuilding and Radiographic Department. Previous experience desirable but not essential as training can be given to applicant with suitable scientific background. Minimum educational requirement is the General Certificate of Education and the age range between 20 and 30. Replies should be addressed to LABOUR MANAGER, Vickers-Armstrongs (Engineers) Limited, Barrow-in-Furness, Lancashire.

SITUATIONS VACANT—*contd.*

R. & A. MAIN, LTD., invite applications for the position of ASSISTANT GENERAL MANAGER at their Edmonton Works. Applicants should have an engineering background with a University Degree or Corporate Membership of one of the recognised Institutions. Age between 30 and 45. Administration ability is important. Excellent future prospects are offered with an attractive salary and contributory pension scheme. Please address applications in confidence to the GENERAL MANAGER, R. & A. Main, Ltd., Angel Road, Edmonton, London, N.18.

HEAD CHEMIST required for laboratory serving Iron and Steel Foundries on Tyneside; must be capable of taking control of all chemical analyses appertaining to castings and raw materials. Canteen; 5-day week; Pension Fund.—Reply, stating age, experience, and salary expected, to Box HC491, FOUNDRY TRADE JOURNAL.

A LARGE Midlands Foundry requires a first-class man with a proved record of technical knowledge and organizing ability, together with a wide experience of modern production methods, for automobile castings. This position offers an assured career of unlimited advancement to the right man, and the salary contemplated will be commensurate with the responsibility.

This is a high executive post for a man between the ages of 35 and 45 with the ability to think clearly and constructively.

Applications should state age, education, present salary and the fullest possible details of experience and positions held. Box AL485, FOUNDRY TRADE JOURNAL.

A.P.V.—PARAMOUNT LIMITED require CORE SHOP FOREMAN having first-class organising ability and with extensive experience in high quality core production, ferrous and/or non-ferrous. Knowledge of latest resin, shell and CO_2 methods an advantage but full technical backing will be provided. Exceptional opportunity for progressive foundryman. Salary commensurate with qualifications; generous pension and profit sharing bonus; excellent working and living conditions. Rented housing available. Apply: FOUNDRY SUPERINTENDENT, A.P.V.-Paramount Ltd., Manor Royal, Crawley, Sussex.

OLD - ESTABLISHED Birmingham Company requires ASSISTANT FOUNDRY FOREMAN. Maximum age 35. Must have served Non-ferrous Moulding apprenticeship. Permanent, pensionable and secure position for suitable applicant. Fares paid for interview. State age, trade qualifications, and practical experience. — Box O.E.502, FOUNDRY TRADE JOURNAL.

FOUNDRY MANAGER required for Foundry making grey iron castings weighing up to two tons. Applicants must have experience of jobbing, plate and machine moulding. Output 25/30 tons per week. Housing accommodation can be arranged. Applicants should state age and salary required and give full particulars of qualifications and previous experience to Box FM498, FOUNDRY TRADE JOURNAL.

SITUATIONS VACANT—*contd.*

SENTINEL (SHREWSBURY) LIMITED, Shrewsbury, require practical experienced FOREMEN capable of obtaining results in the following Foundry departments:—

Machine Moulding.
Core Making.
Fettling.

The appointments carry an attractive salary to competent men and a Pension Scheme is in operation. Apply in confidence to the PERSONNEL MANAGER, Sentinel (Shrewsbury) Limited, giving full details of age, education, training and positions held with dates.

GREY IRONFOUNDERS in West Midlands seek the services of young FOUNDRY FOREMAN, 25/35. Applicant must have served apprenticeship and have reasonable knowledge of Jobbing Foundry practices. Excellent opportunity for keen and energetic man.—Write, giving full particulars, Box GI493, FOUNDRY TRADE JOURNAL.

FOREMAN required for aluminium alloy sand foundry in South-London area. Applicants should be fully experienced in all modern methods of sand rammer, shell, and jolt-squeeze moulding machines; coremaking; cost estimating; melting and metal-preparation techniques. Only first-class men need apply, giving full details of experience, age, etc., to Box FR470, FOUNDRY TRADE JOURNAL.

TECHNICAL SALES REPRESENTATIVE required by an expanding division of an East Midland Engineering Firm entering the Foundry Plant and Machinery field, to guide development as well as taking full responsibility for sales. Candidates should have wide sales experience, preferably including shell moulding and other modern techniques. The appointment will carry a salary appropriate to the qualifications and experience of the man chosen. The Company provide excellent conditions of employment, Pension Scheme, etc. Applications, which will be treated confidentially, should include details of age, qualifications and previous experience, including salaries earned, and should be addressed to PERSONNEL MANAGER, Box TS482, FOUNDRY TRADE JOURNAL.

FOUNDRY MANAGER required by Midland Ironfoundry producing at present approx. 100 tons weekly, with scope for considerable increase in production. Suitable applicants must be capable of taking full charge, and be keen, energetic and efficient. The ability to show initiative and to act upon it, to maintain production programmes and to control staff and labour being essential. Opportunity to join Board afforded to engaged applicant after agreed trial period. Apply stating experience, age and salary required to Box FM466, FOUNDRY TRADE JOURNAL.

BROWN, LENOX & CO., LTD., Pontypridd, require the services of an experienced METALLURGICAL LABORATORY ASSISTANT conversant with Steel Foundry Sand techniques. Applicants with training in a similar capacity will be considered. Apply WORKS METALLURGIST, Pontypridd.